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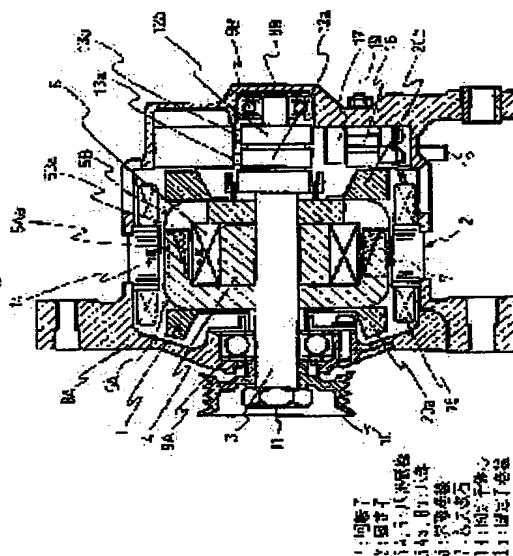
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## (54) ALTERNATOR FOR VEHICLE

## (57)Abstract:

**PROBLEM TO BE SOLVED:** To provide an alternator for a vehicle which can improve an output by effectively utilizing a magnetic flux of a permanent magnet disposed between claw magnetic poles.

**SOLUTION:** In the alternator for a vehicle, in which the permanent magnet 7 is disposed between a plurality of claw portions 5Aa, 5Ba provided to a pair of claw type magnetic poles 5A, 5B arranged opposed to each other, and a rotor 1 wound with a field coil 6 in the internal side of the diameter direction relative to the plurality of claw portions 5Aa, 5Ba and a stator 2 wound with a stator coil 15 at its stator iron core 14 are also provided. Moreover, the claw portions 5Aa, 5Ba of the rotor 1 are formed in a shape so as to be in contact with the entire surface of the magnetic poles of the permanent magnet 7.



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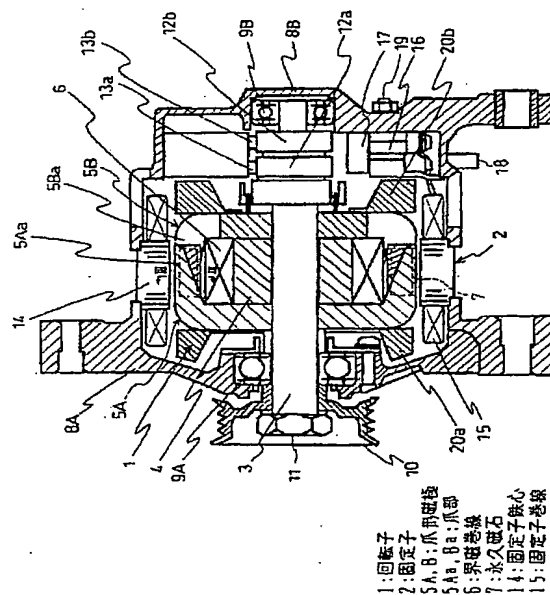
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(54) 【発明の名称】 車両用交流発電機

(57) 【要約】

【課題】 爪磁極間に配置した永久磁石の磁束を有効に活用することにより、出力を向上することができる車両用交流発電機を提供する。

【解決手段】 対向配置された一对の爪形磁極5A、5Bにそれぞれ複数設けた爪部5Aa、5Ba間に永久磁石7を配置し、複数の爪部5Aa、5Baに対しその径方向内側に界磁巻線6を巻回した回転子1と、固定子鉄心14に固定子巻線15を巻回した固定子2とを備えた車両用交流発電機に、回転子1の爪部5Aa、5Baを、永久磁石7の磁極面全面と接触するような形状とする。



【特許請求の範囲】

【請求項 1】対向配置された一対の爪形磁極にそれぞれ複数設けた爪部間に永久磁石を配置し、前記複数の爪部に対しその径方向内側に界磁巻線を巻回した回転子と、固定子鉄心に固定子巻線を巻回した固定子とを備えた車両用交流発電機において、前記回転子の爪部を、前記永久磁石の磁極面全面と接触するような形状としたことを特徴とする車両用交流発電機。

【請求項 2】請求項 1 記載の車両用交流発電機において、前記爪部は、前記永久磁石の前記磁極面全面と接触する補助磁極部を有することを特徴とする車両用交流発電機。

【請求項 3】請求項 2 記載の車両用交流発電機において、前記補助磁極部は、その前記回転子の径方向内側の幅寸法に比べ、前記回転子の径方向外側の幅寸法の方が相対的に厚く形成されていることを特徴とする車両用交流発電機。

【請求項 4】請求項 1 記載の車両用交流発電機において、前記爪部を、その前記回転子の径方向内側の面が、前記回転子の径方向外側の面に対して略平行となるように形成したことを特徴とする車両用交流発電機。

【請求項 5】請求項 4 記載の車両用交流発電機において、前記複数の爪部を略リング状の連結部材で連結したことを特徴とする車両用交流発電機。

【請求項 6】請求項 1～5 のいずれか 1 項記載の車両用交流発電機において、前記爪部は、前記永久磁石を保持する磁石保持部を有することを特徴とする車両用交流発電機。

【請求項 7】対向配置された一対の爪形磁極にそれぞれ複数設けた爪部間に永久磁石を配置し、前記複数の爪部に対しその径方向内側に界磁巻線を巻回した回転子と、固定子鉄心に固定子巻線を巻回した固定子とを備えた車両用交流発電機において、前記爪部と前記永久磁石との間に、前記永久磁石の磁極面全面と接触する補助磁極板を介設したことを特徴とする車両用交流発電機。

【請求項 8】請求項 7 記載の車両用交流発電機において、前記補助磁極板は、前記永久磁石を保持する磁石保持部を有することを特徴とする車両用交流発電機。

【請求項 9】請求項 1～8 のいずれか 1 項記載の車両用交流発電機において、前記永久磁石の少なくとも前記回転子の径方向外側に保護部材を配設したことを特徴とする車両用交流発電機。

【発明の詳細な説明】

【0001】

【発明の属する技術分野】本発明は車両用交流発電機に係り、特に補助励磁用の永久磁石を備えた車両用交流発電機に関する。

【0002】

【従来の技術】通常、車両用交流発電機は回転子と固定子から構成され、一般的に、回転子は、対向配置された一対の爪形磁極と、これら爪形磁極にそれぞれ複数設けられた爪部に対してその径方向内側に巻回され、電流を流すことにより先の一対の爪形磁極を N 極及び S 極に磁化させる界磁巻線とからなる。また、固定子は、固定子鉄心に出力用の固定子巻線を巻回したもので、先の回転子はこの固定子に対して相対的に回転するようになっている。

【0003】このような構造により、N 極に磁化した爪形磁極から出た磁束は、固定子鉄心を介して S 極に磁化した爪形磁極に戻る磁気回路を形成し、この磁気回路の磁束が固定子の固定子巻線に差交し、また回転子が回転することにより、固定子巻線に交流の誘起電圧が発生するようになっている。

【0004】ここで、このような構造の車両用交流発電機においては、例えば爪形磁極間に補助励磁用の永久磁石を介在させることにより、爪形磁極間での漏洩磁束を減じるとともに、界磁巻線の磁束を増磁させ、発電機の出力を向上させることが行われている。このように、爪形磁極間に補助励磁用の永久磁石を配置した車両用交流発電機としては、例えば、特開平 11-318064 号公報に記載された車両用交流発電機等がある。

【0005】

【発明が解決しようとする課題】しかしながら、上記従来技術には、以下の課題が存在する。通常、爪形磁極の爪部は、その先端部を軽量化するため、回転子の軸方向の断面形状が先端が細くなるようにほぼ三角形に形成されている。これは、爪形磁極の爪部が片持ち支持構造であるため、回転子が高速回転する場合等に、爪部の先端部が遠心力により回転子の径方向外側へ起き上がることを防止するように配慮されているためである。そのため、回転子の径方向の厚みが比較的厚い永久磁石を爪形磁極間に配置した場合には、永久磁石の回転子の周方向の側面（すなわち磁極面）に爪部と接触しない部分が生じ、永久磁石の作る磁気回路への磁気抵抗が増大するため、永久磁石の磁束が有効に活用されていない場合がある。

【0006】上記従来技術においても、爪部の回転子の軸方向の断面形状が先端が細くなるようにほぼ三角形となっている。また、この従来技術においては、回転子の径方向の厚みが比較的薄い永久磁石を用いているが、爪部の永久磁石との接触面形状に対しては特に考慮されておらず、やはり爪部の先端部付近において、永久磁石の磁極面に爪部と接触しない部分が存在し、永久磁石の磁束が有効に活用されていない可能性がある。

【0007】本発明の目的は、爪形磁極間に配置した永久磁石の磁束を有効に活用することにより、出力を向上することができる車両用交流発電機を提供することにある。

【0008】

【課題を解決するための手段】(1) 上記目的を達成するために、本発明は、対向配置された一対の爪形磁極にそれぞれ複数設けた爪部間に永久磁石を配置し、前記複数の爪部に対しその径方向内側に界磁巻線を巻回した回転子と、固定子鉄心に固定子巻線を巻回した固定子とを備えた車両用交流発電機において、前記回転子の爪部を、前記永久磁石の磁極面全面と接触するような形状とする。

【0009】前述のように、通常、爪形磁極の爪部は、回転子の軸方向の断面形状が先端が細くなるようにほぼ三角形に形成されているため、回転子の径方向の厚みが比較的厚い永久磁石を爪形磁極間に配置した場合には、永久磁石の回転子の周方向の側面(磁極面)に爪部と接触しない部分が生じる。すなわち、永久磁石の作る磁気回路への磁気抵抗が増大するため、永久磁石の磁束が有効に活用されない場合がある。

【0010】そこで本発明においては、爪形磁極の爪部を永久磁石の磁極面全面と接触するように形成する。これにより、永久磁石から出た磁束は、ほぼ全てが爪部に入るので、永久磁石の作る磁気回路に作用する磁気抵抗を小さくすることができる。したがって、爪磁極間に配置した永久磁石の磁束を有効に活用することができ、車両用交流発電機の出力を向上することができる。

【0011】(2) 上記(1)において、好ましくは、前記爪部は、前記永久磁石の前記磁極面全面と接触する補助磁極部を有する。

【0012】(3) 上記(2)において、好ましくは、前記補助磁極部は、その前記回転子の径方向内側の幅寸法に比べ、前記回転子の径方向外側の幅寸法の方が相対的に厚く形成されている。

【0013】(4) 上記(1)において、また好ましくは、前記爪部を、その前記回転子の径方向内側の面が、前記回転子の径方向外側の面に対して略平行となるように形成する。

【0014】(5) 上記(4)において、好ましくは、前記複数の爪部を略リング状の連結部材で連結する。

【0015】(6) 上記(1)～(5)のいずれか1つにおいて、さらに好ましくは、前記爪部は、前記永久磁石を保持する磁石保持部を有する。

【0016】(7) 上記目的を達成するために、また本発明は、対向配置された一対の爪形磁極にそれぞれ複数設けた爪部間に永久磁石を配置し、前記複数の爪部に対しその径方向内側に界磁巻線を巻回した回転子と、固定子鉄心に固定子巻線を巻回した固定子とを備えた車両用交流発電機において、前記爪部と前記永久磁石との間に、前記永久磁石の磁極面全面と接触する補助磁極板を介設する。

【0017】本発明においては、爪部と永久磁石との間に永久磁石の回転子の周方向側面(磁極面)全面と接触

する補助磁極板を介在させる。これにより、永久磁石から出た磁束は、ほぼ全てが補助磁極板を介して爪形磁極に入るので、永久磁石の作る磁気回路に作用する磁気抵抗を小さくすることができる。したがって、爪磁極間に配置した永久磁石の磁束を有効に活用することができ、車両用交流発電機の出力を向上することができる。

【0018】(8) 上記(7)において、好ましくは、前記補助磁極板は、前記永久磁石を保持する磁石保持部を有する。

【0019】(9) 上記(1)～(8)のいずれか1つにおいて、また好ましくは、前記永久磁石の少なくとも前記回転子の径方向外側に保護部材を配設する。

【0020】

【発明の実施の形態】以下、本発明の実施の形態を図面を用いて説明する。図1は、本発明の車両用交流発電機の第1の実施の形態の全体構造を表す断面図である。この図1において、本実施の形態の車両用交流発電機は、主な構成要素として回転子1と固定子2とを備えている。この回転子1は、シャフト(回転軸)3と、このシャフト3をその回転中心に挿通したヨーク4と、同様にシャフト3をその回転中心に挿通し、ヨーク4を介して回転子1の軸方向(図1中左右方向)に所定間隔を隔てて対向配置され、それぞれ磁性体により構成された一対の爪形磁極5A、5Bと、ヨーク4に巻回した界磁巻線6とから構成されている。

【0021】なお、先の爪形磁極5A、5Bには、それぞれ爪部5Aa、5Baが複数設けられている。これら爪部5Aa、5Baは、図1に示すように、回転子1の周方向から見て、回転子1の軸方向(図1中左右方向)に交互に重なり合うように配置されており、回転子1の周方向に隣接する各爪部5Aa、5Ba間には、それぞれ補助励磁用の永久磁石7が介在して配置されている。また、上記したヨーク4に巻回された界磁巻線6は、これら爪部5Aa、5Baに対し、所定の隙間空間を隔てて回転子1の径方向内側に位置している。

【0022】上記したシャフト3は、エンドブラケット8A、8Bからなる発電機本体に対し、その一方側(図1中左側)端部近傍をベアリング9Aに、他方側(図1中左側)端部をベアリング9Bにより回転自在に支持されている。また、このシャフト3の一方側(図1中左側)端部には、プーリ10がボルト11により締結されており、他方側(図1中左側)端部近傍には、スリップリング12a、12bが設けられている。なお、プーリ10は、例えば、図示しないエンジンのクランクプーリ等とベルト等により連結されている。

【0023】また、先のエンドブラケット8B内部には、スリップリング12a、12bの外周に摺接するようにブラシ13a、13bが設けられており、これらブラシ13a、13b及びスリップリング12a、12bを介し、回転する回転子1の界磁巻線6に電力を供給す

るようになっている。このように界磁巻線6に通電することにより、前述の回転子1の爪形磁極5AがS極に、爪形磁極5BがN極に磁化されるようになっている。

【0024】前述した固定子2は、回転子1の径方向外側（図1で見ると上下側）に、爪部5Aa、5Baと僅かな空隙を隔てて先のエンドブラケット8A、8Bに挟持されて設けられた固定子鉄心14と、この固定子鉄心14に3相に巻回された出力用の固定子巻線15とから構成され、回転子1はこの固定子2に対して相対的に回転するようになっている。すなわち、この固定子2においては、上記のようにN極に磁化した爪形磁極5Bから出た磁束が固定子鉄心14を介してS極に磁化した爪形磁極5Aに戻る磁気回路を形成し、この磁気回路の磁束が固定子巻線15に差交し、また回転子1が回転することにより、固定子巻線15に交流の誘起電圧が発生するようになっている。

【0025】また、先のエンドブラケット8B内部には、整流回路16及び電圧調整器17が設けられている。整流回路16は、バッテリー（図示せず）のプラス電極に接続されるバッテリー端子18と、バッテリー（図示せず）のマイナス電極に接続されるアース端子19とを有し、上記のように固定子巻線15で発生した交流の誘起電圧を整流し直流電圧に変換するようになっている。また、電圧調整器17は、上記図示しないバッテリーを充電するために、整流回路16により整流された直流電圧が、例えば14、5V程度の一定電圧に保たれるように、負荷電流と回転子1の回転数に応じて界磁巻線6に通電する電流を制御するようになっている。

【0026】なお、回転子1の軸方向（図1中左右方向）両側には、固定子2及び整流回路16を空冷する冷却ファン20a、20bがそれぞれ設けられており、その風量は、回転子1の回転数に比例して得られるようになっている。

【0027】上記構成の本実施の形態において、本発明の最も大きな特徴は、前述した回転子1の爪部5Aa、5Baを、永久磁石7の回転子1の周方向側面（すなわち磁極面）全面と接触するような形状としたことである。

【0028】ここで、図2は爪部5Aaの詳細構造を表す側面図、図3は爪部5Aa、5Baと永久磁石7との配置関係を表す図で、先の図1中III-III断面による断面図である。なお、図3には、繁雑防止のため、爪部5Aa、5Baを1極分づつ図示した。すなわち、これら図2及び図3に示すように、爪部5Aa、5Baは、その回転子1の周方向両側部分を除き、図2中破線で示したように従来と同様、回転子1の軸方向（図2中左右方向）の断面が先端方向（図2中右方向）に向かって細くなるような三角形状に形成されている。永久磁石7は、その回転子1の周方向（図3中左右方向）側面（磁極面）がほぼ長方形に形成されており、前述のように爪

部5Aa、5Baの回転子1の軸方向（図2中左右方向）に重なり合った部分の間に介設されている。

【0029】このとき、爪部5Aa、5Baの回転子1の周方向（図3中左右方向）両側の側面（すなわち、爪部5Aa、5Baの重なり合った部分）には、永久磁石7の両磁極面全面と接触する補助磁極部21が設けられている。この補助磁極部21は、本実施の形態においては、永久磁石7の磁極面とほぼ同形状をなすように形成され、永久磁石7に対して密着するようになっている。なお、爪部5Aa、5Baにおける回転子1の周方向（図3中左右方向）両端の回転子1の径方向外側（図3中上側）には、突起状のつば部22が設けられており、回転子1の回転により永久磁石7が飛び出すことを防止するように配慮されている。

【0030】次に上記構成の本実施の形態の車両用交流発電機の動作について説明する。上記のように、まず、例えば図示しないエンジン等から動力を受けて回転する回転子1の界磁巻線6に、ブラシ13a、13b及びスリップリング12a、12bを介して電力が供給され、回転子1の爪形磁極5AがS極に、爪形磁極5BがN極に磁化される。N極に磁化した爪形磁極5Bから出た磁束は、固定子2において、固定子鉄心14を介してS極に磁化した爪形磁極5Aに戻る磁気回路を形成する。このとき、界磁巻線6が作る磁気回路は、補助励磁用の永久磁石7の磁束が加わることにより増磁される。そして、この磁気回路の磁束は、固定子巻線15に差交し、回転子1の回転により固定子鉄心15に3相に巻回された固定子巻線15に交流の誘起電圧が発生する。

【0031】そして最終的に、発生した電圧は整流回路16により整流され直流電圧に変換されて図示しないバッテリーに充電される。またこのとき、この整流回路16により整流された直流電圧を図示しないバッテリーに充電するために、発生電圧が例えば14、5V程度の一定電圧に保たれるよう、負荷電流と回転子1の回転数に応じて界磁巻線6に通電する電流を電圧調整器17により制御する。

【0032】ここで、本実施の形態の作用を以下に順次説明する。

#### （1）高出力化

通常、爪形磁極の爪部は、回転子の軸方向の断面形状が先端が細くなるようにほぼ三角形状に形成されているため、回転子の径方向の厚みが比較的厚い永久磁石を爪形磁極間に配置した場合には、永久磁石の磁極面に爪部と接触しない部分が生じる。すなわち、永久磁石の作る磁気回路への磁気抵抗が増大するため、永久磁石の磁束が有効に活用されない場合がある。

【0033】そこで本実施の形態においては、爪形磁極5A、5Bの爪部5Aa、5Baを永久磁石7の磁極面全面と接触するように形成したので、永久磁石7から出た磁束のほぼ全てを爪部5Aa、5Baに流入させるこ

とができる。これにより、永久磁石7の作る磁気回路に作用する磁気抵抗を小さくすることができ、永久磁石7の磁束を有効に活用することができるので、車両用交流発電機の出力を向上することができる。

#### 【0034】(2) 低価格化

また、本実施の形態においては、上記(1)の作用により、永久磁石7を小型化しても、その磁束が有効に活用され効率的に出力を向上させることができるので、車両用交流発電機の製造コストを低減させることもできる。

#### 【0035】(3) 高温減磁の抑制

例えば、補助励磁用の永久磁石としてネオジム磁石を用いた場合、温度が上昇すると非可逆減磁ポイントの屈曲点に変化するため、パーミアンス係数が低いと磁束密度が低くなる場合(高温減磁)がある。この場合、従来のように、永久磁石の磁極面の全面に接触しない爪形磁極を用いると、その永久磁石の磁極面の爪形磁極に接触しない部分の磁束に対する磁気抵抗が大きくなるので、部分的にパーミアンス係数が下がる場合があった。

【0036】ここで、その磁極が磁性体に接していない永久磁石の動作点と、両磁極が磁性体に接している磁石の動作点とでは、通常、両磁極が磁性体に接している磁石の方が、そのパーミアンス係数が高く、動作点の磁束密度は高くなる。本実施の形態においては、永久磁石7の両磁極が全面爪形磁極5A、5B(厳密には補助磁極部21')に接触しているため、高温減磁に対しての影響を小さくすることができ、永久磁石7の減磁に対する余裕度を上げることができる。

#### 【0037】(4) 永久磁石の着磁容易化

車両用交流発電機の製造方法としては、金属屑等の鉄粉の付着防止等への配慮から、補助励磁用の永久磁石を未着磁の状態では爪形磁極間に配置し、回転子の回転バランスを調整した後、回転子の製造工程の最終段階で例えば外部の着磁ヨーク(図示せず)等により永久磁石を着磁することが一般的に行われている。本実施の形態においては、このような場合、永久磁石7の回転子1の周方向側面の全面に磁性体で構成された爪形磁極5A、5B(厳密には爪部5Aa、5Ba)が接触しているため、未着磁の永久磁石7に対し十分な磁束を通すことができ、永久磁石7の着磁作業を容易にすることができる。

【0038】なお、以上説明してきた本実施の形態においては、先の図3に示したように、爪部5Aa、5Baに設けた補助磁極部21を、その厚み(図3中左右方向の幅)がほぼ一定となるように形成したが、図4に示すように、その先端側(すなわち図4中下側、言い換えれば回転子1の径方向内側)の幅寸法W1と比較して、若干、付根側(すなわち図4中上側、言い換えれば回転子1の径方向外側)の幅W2が相対的に厚くなるように補助磁極部21'を形成することにより、補助磁極部の機械的強度を向上させることができるとともに、永久磁石7から流入する磁束の流れを円滑化することができる。

【0039】また、この図4において、つば部22'には面取りが施されており(ベベルが設けられており)、回転子1の回転する際の各爪部5Aa、5Baと固定子鉄心14との磁気的な断続が円滑になる。これにより固定子2と各爪部5Aa、5Baとの間の空隙における磁束脈動が減少するので、磁気的振動を抑制し、騒音を低減させることができる。なお、図4は、先に説明した第1の実施の形態の図3中A部に相当する部分の詳細構造を表す拡大図である。

10 【0040】本発明の車両用交流発電機の第2の実施の形態を図5を用いて説明する。図5は、本発明の車両用交流発電機の第2の実施の形態に備えられた爪磁極5A、5Bの爪部5Aa<sub>1</sub>、5Ba<sub>1</sub>と永久磁石7との配置関係を表す図で、先の図3に対応する図である。なお、図3と同様の部分には同符合を付し説明を省略するとともに、必要に応じて先の各図も参照する。また、この図5においても図3と同様、繁雑防止のため爪部5Aa<sub>1</sub>、5Ba<sub>1</sub>を1極分ずつ図示した。繁雑防止のため特に図示しないが、爪部5Aa<sub>1</sub>、5Ba<sub>1</sub>は、従来のように、上記つば部22の部分を除き、その回転子1の軸方向(図5中紙面直交方向)の断面形状が先端が細くなるようにほぼ三角形に形成されている。そして図5に示すように、本実施の形態においては、このような形状の爪部5Aa<sub>1</sub>、5Ba<sub>1</sub>と永久磁石7との間に、永久磁石7の磁極面全面と接触し、磁性体により構成された補助磁極板23を介設している。その他の構成は、第1の実施の形態と同様である。

30 【0041】本実施の形態においては、上記のように、爪部5Aa<sub>1</sub>、5Ba<sub>1</sub>と永久磁石7との間に永久磁石7の磁極面全面と接触する補助磁極板23を介在させることにより、永久磁石7から出た磁束は、ほぼ全てが補助磁極板23を介して爪形磁極5A、5Bに入るため、永久磁石7の作る磁気回路に作用する磁気抵抗を小さくすることができる。したがって、第1の実施の形態と同様、爪磁極5A、5B間に配置した永久磁石7の磁束を有効に活用することができ、車両用交流発電機の出力を向上することができる。

40 【0042】なお、本実施の形態における永久磁石7の着磁の際には、予め永久磁石7の着磁面(図5中左右両面)に補助磁極板23を接着したものを隣接する爪部5Aa<sub>1</sub>、5Ba<sub>1</sub>間に配置し、その後外部の着磁ヨーク(図示せず)により着磁する。この着磁は、前にも説明したように、冷却ファン20a、20b(図1参照)の取付け及びバランス取りを行った後、回転子1の製造工程の最終段階で行うのが望ましい。このような手順を踏むことで、金属屑等の鉄粉の付着を防止することができ、信頼性の高い車両用交流発電機とすることができる。

50 【0043】本発明の車両用交流発電機の第3の実施の形態を図6を用いて説明する。図6は、本発明の車両用

交流発電機の第3の実施の形態に備えられた爪磁極5A、5Bの爪部5Aa<sub>2</sub>、5Ba<sub>2</sub>と永久磁石7との配置関係を表す図で、先の図3に対応する図である。なお、図3と同様の部分には同符合を付し説明を省略するとともに、必要に応じて先の各図も参照する。また、この図6においても図3と同様、繁雑防止のため爪部5Aa<sub>2</sub>、5Ba<sub>2</sub>を1極分づつ図示した。繁雑防止のため特に図示しないが、爪部5Aa<sub>2</sub>、5Ba<sub>2</sub>を、その回転子1の径方向内側(図6中下側)の面が、回転子1の径方向外側(図6中上側)の面に対して略平行となるように形成している。すなわち、爪部5Aa<sub>2</sub>、5Ba<sub>2</sub>の全体の厚みは、先端部から根元部までほぼ同じで、その回転子1の軸方向(図6中紙面直交方向)の断面形状は、ほぼ長方形に形成されている。

【0044】このような構造により、永久磁石7の回転子1の周方向(図6中左右方向)側面(磁極面)は、磁性体により構成された爪部5Aa<sub>2</sub>、5Ba<sub>2</sub>に対し全面密着している。その他の構成は、第1の実施の形態と同様であり、本実施の形態においても、同様の効果を得る。

【0045】なお、本実施の形態は、例えば建設機械等に用いる車両用交流発電機に好適である。すなわち、爪部5Aa<sub>2</sub>、5Ba<sub>2</sub>は、先端部を根元部とほぼ同じ厚みで形成したため、先端部の重量が、第1及び第2の実施の形態に用いた爪部5Aa<sub>1</sub>、5Ba<sub>1</sub>、5Aa<sub>2</sub>、5Ba<sub>2</sub>と比較して重いため、回転子1(図1参照)の回転により回転子1の径方向外側(図6中上側)に起き上がる可能性があるが、例えば建設機械等に用いる車両用交流発電機等は、通常3000~4000rpm程度の比較的小さい回転数で定速回転するため、遠心力に対して爪部5Aa<sub>2</sub>、5Ba<sub>2</sub>の付け根部分に働く応力が小さく、爪部5Aa<sub>2</sub>、5Ba<sub>2</sub>が上記のように起き上がる可能性は小さい。また、上記形状の本実施の形態における爪部5Aa<sub>2</sub>、5Ba<sub>2</sub>においては、永久磁石7から流入する磁束の流れが円滑となるので、高い出力が要求される建設機械等に用いる車両用交流発電機に好適となる。

【0046】また、この第3の実施の形態の車両用交流発電機を高速回転させる場合、図7に示すように、各爪部5Aa<sub>2</sub>、5Ba<sub>2</sub>を、例えばその回転子1の径方向内側から略リング状の連結リング24で連結すればよい。この連結リング24は、各爪部5Aa<sub>2</sub>、5Ba<sub>2</sub>に対し、それぞれネジ25により固定されている(固定方法としては、特にこれに限られず、例えば溶接等により固定してもよい)。このとき、連結リング24は非磁性体で、ネジ25は磁性体で構成することが望ましい。なお、図7では、繁雑防止のため永久磁石7は図示省略している。そして、上記の連結リング24が、請求項5に記載の略リング状の連結部材を構成する。

【0047】ここで、永久磁石7の少なくとも回転子1の径方向外側に保護部材として磁石カバーを配置するこ

とにより、何らかの理由により永久磁石7が割れてしまった場合、回転子1の回転により割れた永久磁石7が回転子1から飛び出すことを防止することができる。以下に、本発明の車両用交流発電機に磁石カバーを設けた変形例を順次説明する。

【0048】図8は、先に説明した本発明の車両用交流発電機の第1の実施の形態に磁石カバーを設けた変形例に備えられた爪磁極5A、5Bの爪部5Aa、5Baと永久磁石7との配置関係を表す図で、先の図3に対応する図である。なお、図3と同様の部分には同符合を付し説明を省略するとともに、必要に応じて先の各図も参照する。また、この図8においても図3と同様、繁雑防止のため爪部5Aa、5Baを1極分づつ図示した。この図8において、永久磁石7の回転子1の径方向外側の面は、これとほぼ同形状の磁石カバー26と密着している。

この磁石カバー26は、爪磁極5A、5B間に配置した永久磁石7の磁束が有効に作用するように、例えばステンレス等の防錆性のよい非磁性体で構成するのが望ましい。本変形例においては、磁石カバー26が爪部22に保持されており、このように磁石カバー26を設けた場合も、永久磁石7の磁極面全面が爪形磁極5A、5B(厳密には爪部5Aa、5Ba)と接触している。

【0049】図9は、先に説明した本発明の車両用交流発電機の第3の実施の形態に磁石カバーを設けた変形例に備えられた爪磁極5A、5Bの爪部5Aa<sub>2</sub>、5Ba<sub>2</sub>と永久磁石7との配置関係を表す図で、先の図6に対応する図である。なお、図6と同様の部分には同符合を付し説明を省略するとともに、必要に応じて先の各図も参照する。また、この図9においても図6と同様、繁雑防止のため爪部5Aa<sub>2</sub>、5Ba<sub>2</sub>を1極分づつ図示した。この図9においても、先に図8を用いて説明した変形例と同様、永久磁石7の回転子1の径方向外側の面は、これとほぼ同形状の磁石カバー26と密着している。この磁石カバー26は、爪磁極5A、5B間に配置した永久磁石7の磁束が有効に作用するように、例えばステンレス等の防錆性のよい非磁性体で構成するのが望ましい。本変形例においては、磁石カバー26が爪部22に保持されており、このように磁石カバー26を設けた場合も、永久磁石7の磁極面全面が爪形磁極5A、5B(厳密には爪部5Aa<sub>2</sub>、5Ba<sub>2</sub>)と接触している。

【0050】なお、本変形例においても、先の図7で説明した連結リング24により各爪部5Aa<sub>2</sub>、5Ba<sub>2</sub>を連結すれば、回転子1を高速で回転させる場合にも対応できる。

【0051】以上2つの変形例においても、第1の実施の形態と同様の効果を得ることができるとともに、何らかの理由により永久磁石7が割れてしまった場合、回転子1の回転により割れた永久磁石7が回転子1から飛び出すことを防止することができる。

【0052】また、以上2つの変形例における永久磁石



7の着磁の際には、予め永久磁石7の回転子1の径方向外側の面に磁石カバー26を接着したものを隣接する爪形磁極5A、5B間に配置し、その後外部の着磁ヨーク（図示せず）により着磁する。前述したように、この着磁は回転子1の製造工程の最終段階で行うのが望ましく、この場合、金属屑等の鉄粉の付着を防止することができ、信頼性の高い車両用交流発電機とすることができる。

【0053】なお、以上2つの変形例においては、板状の磁石カバー26で永久磁石7の回転子1径方向外側の面を保護する構造としたが、これに限られる必要はない。すなわち、永久磁石7の磁極面以外の面は磁気特性に影響を与えないため、磁石カバーは、例えば磁極面以外の4面を囲んでしまうような形状としてもよく、要は磁石カバーの形状は、その技術的思想を逸脱しない範囲で種々に変形させて構わない。以下に、このような永久磁石7の磁極面以外の4面を囲む磁石カバーを設けた本発明の車両用交流発電機の変形例を図10及び図11を用いて説明する。

【0054】図10は先に説明した本発明の車両用交流発電機の第2の実施の形態に磁石カバーを設けた変形例に備えられた爪磁極5A、5Bの爪部5Aa<sub>1</sub>、5Ba<sub>1</sub>と永久磁石7との配置関係を表す図で、先の図5に対応する図である。図11はこの磁石カバーの全体構造を表す斜視図である。なお、図10において、図5と同様の部分には同符合を付し説明を省略するとともに、必要に応じて先の各図も参照する。また、この図10においても図5と同様、繁雑防止のため爪部5Aa<sub>1</sub>、5Ba<sub>1</sub>を1極分づつ図示した。これら図10及び図11に示すように、磁石カバー26Aは永久磁石7の磁極面以外の4面を囲むような枠形状で、永久磁石7の磁極面以外の4面と極力密着するように、その内周側壁面は精度よく加工されている。また、この磁石カバー26Aも、爪磁極5A、5B間に配置した永久磁石7の磁束が有効に作用するように、例えばステンレス等の防錆性のよい非磁性体で構成するのが望ましい。本変形例においても、磁石カバー26Aが爪部22に保持されており、このように磁石カバー26Aを設けた場合も、永久磁石7の磁極面全面が爪形磁極5A、5B（厳密には爪部5Aa<sub>1</sub>、5Ba<sub>1</sub>）と接触している。

【0055】本変形例においても、第1の実施の形態と同様の効果を得ることができるとともに、何らかの理由により永久磁石7が割れてしまった場合、回転子1の回転により割れた永久磁石7が回転子1から飛び出すことを防止することができる。

【0056】なお、本実施の形態における永久磁石7の着磁の際には、まず、枠状に形成された磁石カバー26Aの内周側に未着磁の永久磁石7を差し込み、この状態で永久磁石7の磁極面に補助磁極板23、23を配置する。図10からも分かるように、補助磁極板23の寸法

は、磁石カバー26Aの回転子1の周方向（図10中左右方向）側面とほぼ同一で、永久磁石7は、磁石カバー26Aと補助磁極板23、23とを例えば溶接等により接続して構成された箱の内壁面に精度よく収まっている。

【0057】そして、磁石カバー26A、補助磁極板23、23、及び永久磁石7を一体的に組立てた状態で、これを補助磁極板23、23が爪部5Aa<sub>1</sub>、5Ba<sub>1</sub>と接触するように、隣接する爪部5Aa<sub>1</sub>、5Ba<sub>1</sub>間に配置し、その後外部の着磁ヨーク（図示せず）により着磁する。この着磁も前述と同様、回転子1の製造工程の最終段階で行うのが望ましい。このような手順を踏むことで、金属屑等の鉄粉の付着を防止することができ、信頼性の高い車両用交流発電機とすることができる。

【0058】以上3つの変形例において、上記磁石カバー26、26Aが、請求項9に記載の保護部材を構成する。

【0059】また、上記した磁石カバー26、26Aは、先に説明した第1～第3の実施の形態と、任意に組合せ可能であることは言うまでもない。

【0060】またここで、爪部の回転子周方向側面、補助磁極部、及び補助磁極板等、永久磁石と接触する部分に永久磁石を機械的に保持する磁石保持部を設けることにより、未着磁時の永久磁石が爪磁極間から脱落することを防止でき、回転子の組立作業、永久磁石の着磁作業等の作業性を向上させることができる。以下に、本発明の車両用交流発電機に磁石保持部を設けた変形例を順次説明する。

【0061】図12は、先に説明した本発明の車両用交流発電機の第1の実施の形態に磁石保持部を設けた変形例に備えられた爪磁極5A、5Bの爪部5Aa<sub>3</sub>、5Ba<sub>3</sub>と永久磁石7との配置関係を表す図で、先の図3に対応する図である。なお、図3と同様の部分には同符合を付し説明を省略するとともに、必要に応じて先の各図も参照する。また、この図12においても図3と同様、繁雑防止のため爪部5Aa<sub>3</sub>、5Ba<sub>3</sub>を1極分づつ図示した。この図12に示すように、本変形例においては、各補助磁極部21Aの回転子1の径方向内側（図12中下側）端部には、それぞれ磁石保持部21Aaが、爪部22との間に永久磁石7を挟み込むように設けられている。このように磁石保持部21Aaを設けた場合も、永久磁石7の磁極面全面が爪形磁極5A、5B（厳密には爪部5Aa<sub>3</sub>、5Ba<sub>3</sub>）と接触している。その他の構成は第1の実施の形態と同様である。なお、本変形例の磁石保持部21Aaは、先に説明した第3の実施の形態にも適用可能であることは言うまでもない。

【0062】図13は、先に説明した本発明の車両用交流発電機の第2の実施の形態に磁石保持部を設けた変形例に備えられた爪磁極5A、5Bの爪部5Aa<sub>1</sub>、5Ba<sub>1</sub>と永久磁石7との配置関係を表す図で、先の図5に

対応する図である。なお、図5と同様の部分には同符合を付し説明を省略するとともに、必要に応じて先の各図も参照する。また、この図13においても図5と同様、繁殖防止のため爪部5Aa<sub>1</sub>、5Ba<sub>1</sub>を1極分づつ図示した。この図13に示すように、本変形例においては、各補助磁極板23Aの回転子1の径方向内側(図13中下側)端部には、それぞれ磁石保持部23Aaが、爪部22との間に永久磁石7を挟み込むように設けられている。このように磁石保持部23Aaを設けた場合も、永久磁石7の磁極面全面が補助磁極板23Aと接触している。その他の構成は第2の実施の形態と同様である。

【0063】図14は、先に説明した本発明の車両用交流発電機の第2の実施の形態に磁石保持部を設けた他の変形例に備えられた爪磁極5A、5Bの爪部5Aa<sub>1</sub>、5Ba<sub>1</sub>と永久磁石7との配置関係を表す図で、先の図5に対応する図である。なお、図5と同様の部分には同符合を付し説明を省略するとともに、必要に応じて先の各図も参照する。また、この図14においても図5と同様、繁殖防止のため爪部5Aa<sub>1</sub>、5Ba<sub>1</sub>を1極分づつ図示した。この図14に示すように、本変形例においては、各補助磁極板23Bの回転子1の径方向内側(図13中下側)及び外側(図13中上側)端部には、それぞれ磁石保持部23Ba、23Bbが、永久磁石7を挟み込むように設けられている。そして、爪部22により、磁石保持部23Bbは保持されている。このように磁石保持部23Ba、23Bbを設けた場合も、永久磁石7の磁極面全面が補助磁極板23Bと接触している。その他の構成は第2の実施の形態と同様である。

【0064】なお、図13及び図14を用いて説明した2つの本変形例における永久磁石7の着磁の際には、予め永久磁石7の着磁面(図13及び図14中左右両面)に補助磁極板23A、23Bを接着したものを隣接する爪部5Aa<sub>1</sub>、5Ba<sub>1</sub>間に配置し、その後外部の外部の着磁ヨーク(図示せず)により着磁する。この着磁も、前述と同様、回転子1の製造工程の最終段階で行うのが望ましい。このような手順を踏むことで、金属屑等の鉄粉の付着を防止することができ、信頼性の高い車両用交流発電機とすることができる。また特に、図14で説明した変形例においては、補助磁極板23Bの図中上下方向の形状がほぼ同様であるため、永久磁石7の着磁面に補助磁極板23Bを接着したものを爪形磁極5A、5B間に配置する際、その上下方向の向きを気にしなくてもよく、作業性が向上する。

【0065】以上3つの変形例においても、先の第1の実施の形態と同様の効果が得られるとともに、未着磁時の永久磁石7が爪磁極5A、5B間から界磁巻線6側に脱落することを防止でき、回転子1の組立作業、永久磁石7の着磁作業等の作業性を向上させることができる。

【0066】なお、実際には加工公差、面粗度等により厳密に永久磁石の磁極面全面と接触するように、爪部の

回転子周方向側面、補助磁極部、及び補助磁極板等を形成することは難しく、ミクロ的に見た場合、爪部の回転子周方向側面、補助磁極部、及び補助磁極板等と永久磁石の磁極面全面とは、完全に接触していない(ほぼ覆っているにとどまる)可能性もあるが、これらのような場合も、爪部の回転子周方向側面、補助磁極部、及び補助磁極板等と、永久磁石の磁極面全面とは、事実上ほぼ接触していると考えることができ、ほぼ同様の効果を得ることができる。

【0067】また、先の図4を用いて説明した補助磁極部21'の強度補強及び磁束の流れの円滑化、つば部22'の騒音低減の構造は、以上説明してきた各実施の形態及び変形例にも適用可能であることは言うまでもない。

【0068】さらに、以上は、回転する界磁巻線6に対し、ブラシ13a、13bを設けて電力を供給する型の車両用交流発電機を例にとって説明したが、例えば界磁巻線が固定されたブラシレスタイプの車両用交流発電機等に対しても、本発明は適用可能であり、要は爪磁極間に永久磁石を配置するものであれば同様の効果が得られることは言うまでもない。

【0069】また、永久磁石7が回転子1の回転等により回転子1外に飛び出すことを防止する構造としては、つば部22、22'等を設ける構造としたが、これに限られず、例えば爪部の回転子周方向の幅寸法を、回転子径方向内側よりも外側を広くし、その回転子周方向の幅寸法を、回転子径方向外側よりも内側を広く形成した台形状の永久磁石を爪部間に配置する構造とすれば、つば部22、22'は省略することもできる。

【0070】

【発明の効果】請求項1に記載の発明によれば、爪形磁極の爪部を永久磁石の磁極面全面と接触するように形成することにより、永久磁石から出た磁束は、ほぼ全てが爪部に入るので、永久磁石の作る磁気回路に作用する磁気抵抗を小さくすることができる。したがって、爪磁極間に配置した永久磁石の磁束を有効に活用することができる。車両用交流発電機の出力を向上することができる。

【0071】請求項7に記載の発明によれば、爪部と永久磁石との間に永久磁石の回転子の磁極面全面と接触する補助磁極板を介在させることにより、永久磁石から出た磁束は、ほぼ全てが補助磁極板を介して爪形磁極に入るため、永久磁石の作る磁気回路に作用する磁気抵抗を小さくすることができる。したがって、爪磁極間に配置した永久磁石の磁束を有効に活用することができ、車両用交流発電機の出力を向上することができる。

【図面の簡単な説明】

【図1】本発明の車両用交流発電機の第1の実施の形態の全体構造を表す断面図である。

【図2】本発明の車両用交流発電機の第1の実施の形態に備えられた爪部の詳細構造を表す側面図である。

【図 3】本発明の車両用交流発電機の第 1 の実施の形態に備えられた爪部と永久磁石との配置関係を表す図で、図 1 中 III-III 断面による断面図である。

【図 4】本発明の車両用交流発電機の第 1 の実施の形態に備えられた補助磁極部の補強及び磁束の流れの円滑化、騒音低減の構造を設けた変形例の構造を表す図で、図 3 中 A 部に相当する部分の拡大図である。

【図 5】本発明の車両用交流発電機の第 2 の実施の形態に備えられた爪磁極の爪部と永久磁石との配置関係を表す図で、図 3 に対応する図である。

【図 6】本発明の車両用交流発電機の第 3 の実施の形態に備えられた爪磁極の爪部と永久磁石との配置関係を表す図で、図 3 に対応する図である。

【図 7】本発明の車両用交流発電機の第 3 の実施の形態に備えられた各爪部を連結リングで連結した変形例の詳細構造を表す斜視図である。

【図 8】本発明の車両用交流発電機の第 1 の実施の形態に磁石カバーを設けた変形例に備えられた爪磁極の爪部と永久磁石との配置関係を表す図で、図 3 に対応する図である。

【図 9】本発明の車両用交流発電機の第 3 の実施の形態に磁石カバーを設けた変形例に備えられた爪磁極の爪部と永久磁石との配置関係を表す図で、図 6 に対応する図である。

【図 10】本発明の車両用交流発電機の第 2 の実施の形態に磁石カバーを設けた変形例に備えられた爪磁極の爪部と永久磁石との配置関係を表す図で、図 5 に対応する図である。

【図 11】図 10 に示した磁石カバーの全体構造を表す斜視図である。

【図 12】本発明の車両用交流発電機の第 1 の実施の形態に磁石保持部を設けた変形例に備えられた爪磁極の爪部と永久磁石との配置関係を表す図で、図 3 に対応する \*

\* 図である。

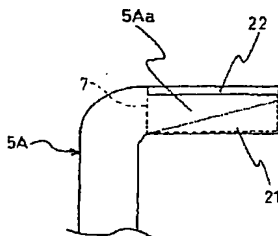
【図 13】本発明の車両用交流発電機の第 2 の実施の形態に磁石保持部を設けた変形例に備えられた爪磁極の爪部と永久磁石との配置関係を表す図で、図 5 に対応する図である。

【図 14】本発明の車両用交流発電機の第 2 の実施の形態に磁石保持部を設けた他の変形例に備えられた爪磁極の爪部と永久磁石との配置関係を表す図で、図 5 に対応する図である。

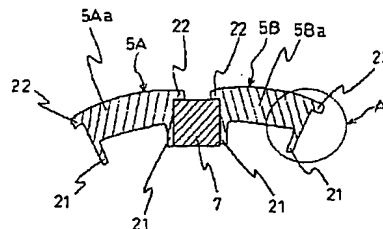
# 【符号の説明】

1	回転子
2	固定子
5 A, B	爪形磁極
5 A a, B a	爪部
5 A a <sub>1</sub> , B a <sub>1</sub>	爪部
5 A a <sub>2</sub> , B a <sub>2</sub>	爪部
5 A a <sub>3</sub> , B a <sub>3</sub>	爪部
6	界磁巻線
7	永久磁石
20	14
	15
	21
	21'
	21 A
	21 A a
	23
	23 A, B
	23 A a
	23 B a, b
30	24
	26
	26 A
	連結リング（連結部材）
	保護部材（保護カバー）
	保護部材（保護カバー）

【図 2】

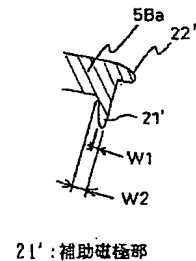


【図 3】



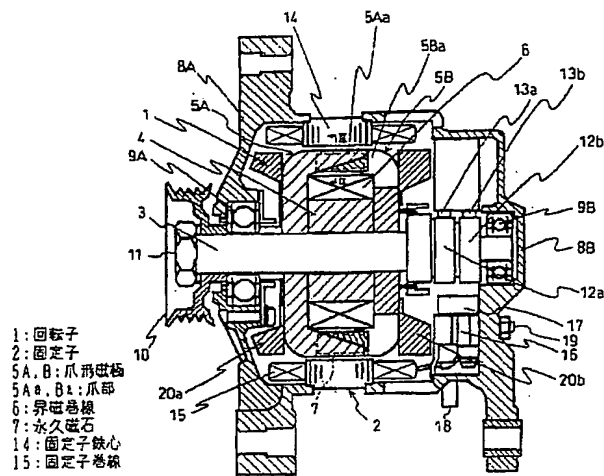
5 A, B: 爪形磁極  
5 A a, B a: 爪部  
21: 補助磁極部

【図 4】

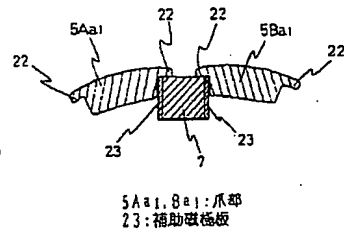


21': 補助磁極部

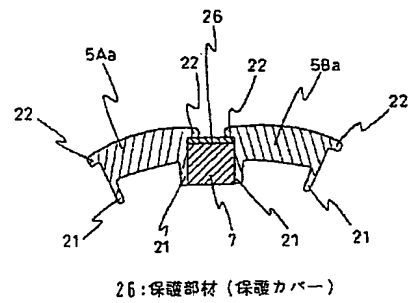
【図1】



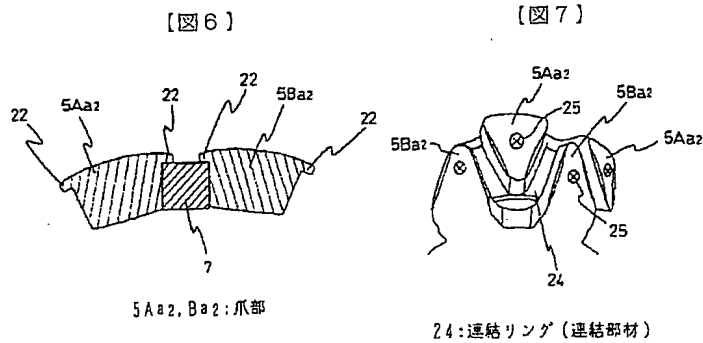
【図5】



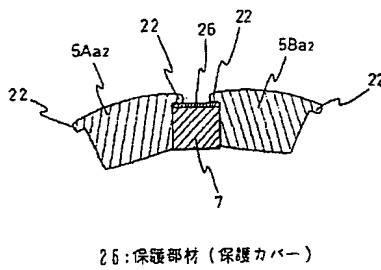
【図8】



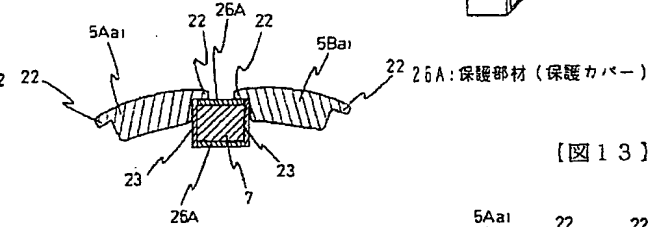
【図11】



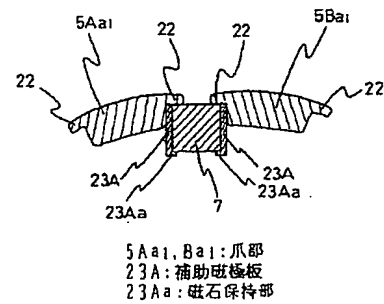
【図9】



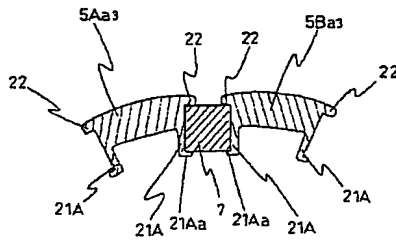
【図10】



【図13】

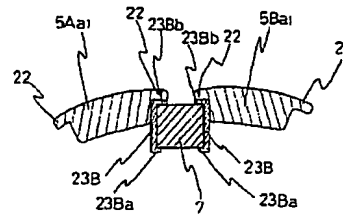


【図 12】



5Aa3, Ba3: 爪部  
21A: 補助磁極部  
21Aa: 磁石保持部

【図 14】



5Aa1, Ba1: 爪部  
23B: 補助磁極部  
23Ba, b: 磁石保持部

## 【手続補正書】

【提出日】平成13年5月16日(2001. 5. 16)

## 【手続補正1】

【補正対象書類名】明細書

【補正対象項目名】0003

【補正方法】変更

## 【補正内容】

【0003】このような構造により、N極に磁化した爪形磁極から出た磁束は、固定子鉄心を介してS極に磁化した爪形磁極に戻る磁気回路を形成し、この磁気回路の磁束が固定子の固定子巻線に鎖交し、また回転子が回転することにより、固定子巻線に交流の誘起電圧が発生するようになっている。

## 【手続補正2】

【補正対象書類名】明細書

【補正対象項目名】0030

## \* 【補正方法】変更

## 【補正内容】

【0030】次に上記構成の本実施の形態の車両用交流発電機の動作について説明する。上記のように、まず、例えば図示しないエンジン等から動力を受けて回転する回転子1の界磁巻線6に、ブラシ13a, 13b及びスリップリング12a, 12bを介して電力が供給され、回転子1の爪形磁極5AがS極に、爪形磁極5BがN極に磁化される。N極に磁化した爪形磁極5Bから出た磁束は、固定子2において、固定子鉄心14を介してS極に磁化した爪形磁極5Aに戻る磁気回路を形成する。このとき、界磁巻線6が作る磁気回路は、補助励磁用の永久磁石7の磁束が加わることで増磁される。そして、この磁気回路の磁束は、固定子巻線15に鎖交し、回転子1の回転により固定子鉄心15に3相に巻回された固定子巻線15に交流の誘起電圧が発生する。

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PP05 PP08 PP25

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PP10

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PP03 PP17 QB08



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(54) **VEHICULAR ALTERNATOR**

**Publication Classification**

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(52) **U.S. Cl.** ..... 310/263

(57) **ABSTRACT**

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A vehicular alternator is provided which can effectively utilize the magnetic flux of a permanent magnet disposed between claw-type magnetic poles and can improve an output of the alternator. The vehicular alternator comprises a rotor and a stator constituted by coiling stator windings over a stator core, the rotor comprising a pair of claw-type magnetic poles arranged in an opposed relation, a permanent magnet disposed between adjacent two of a plurality of claws provided on the pair of claw-type magnetic poles, and field windings coiled radially inward of the plurality of claws. Each of the plurality of claws of the rotor is formed to have a shape coming into contact with the whole of a magnetic pole surface of the permanent magnet.

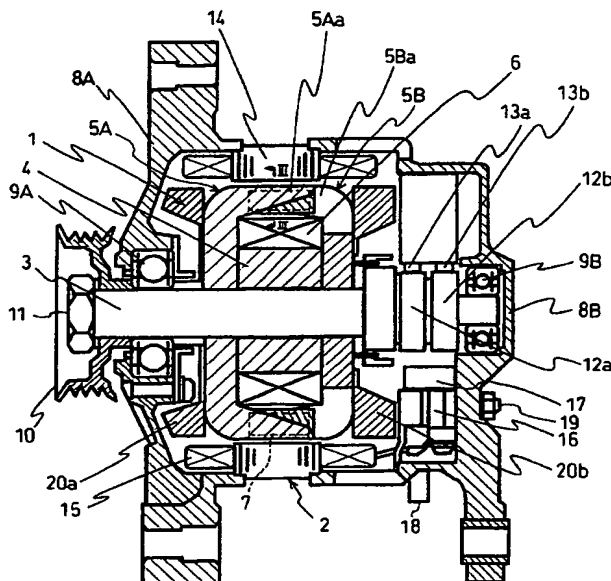
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(22) **Filed:** Aug. 30, 2001

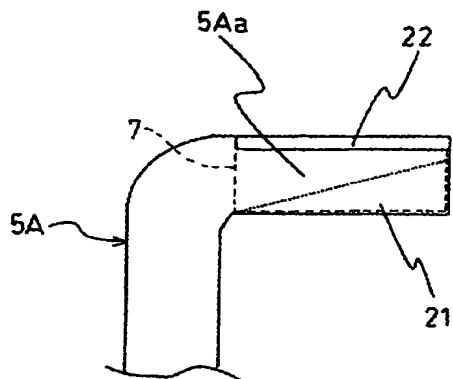
(30) **Foreign Application Priority Data**

Feb. 27, 2001 (JP) ..... 2001-053017

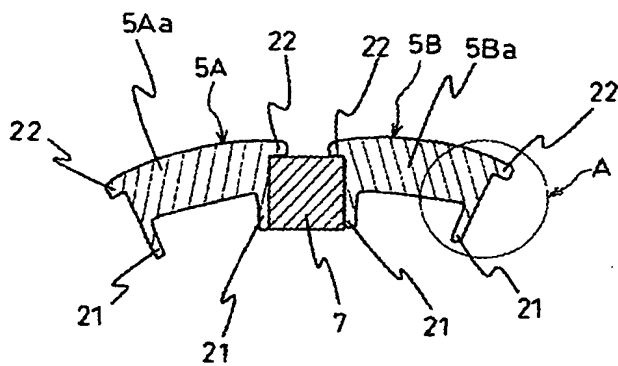




**FIG.2**

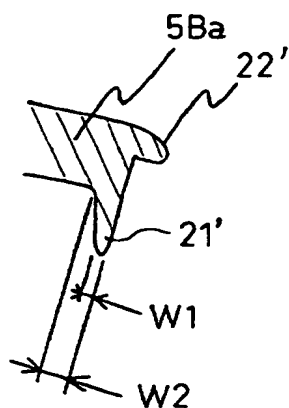


**FIG.3**

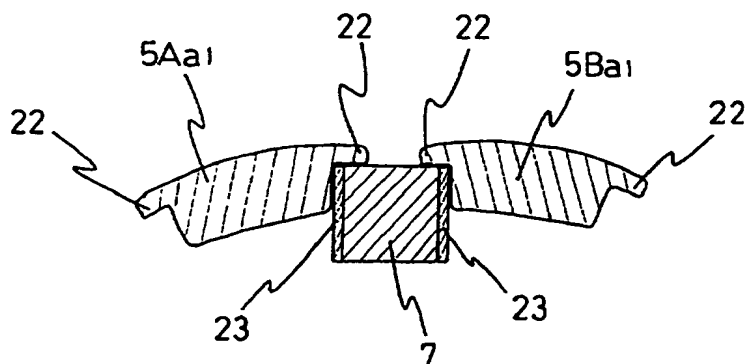




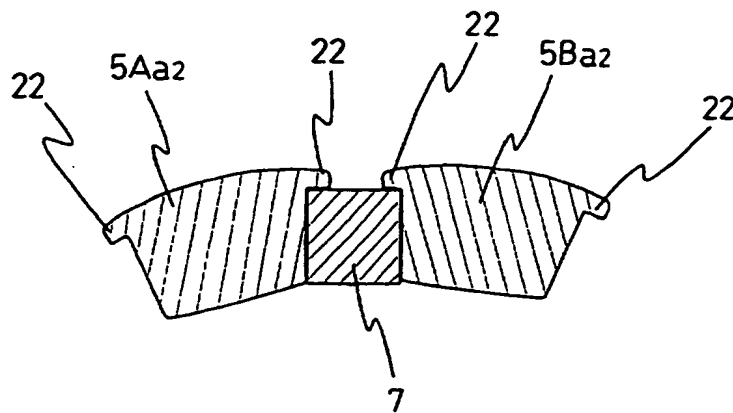
**FIG.4**



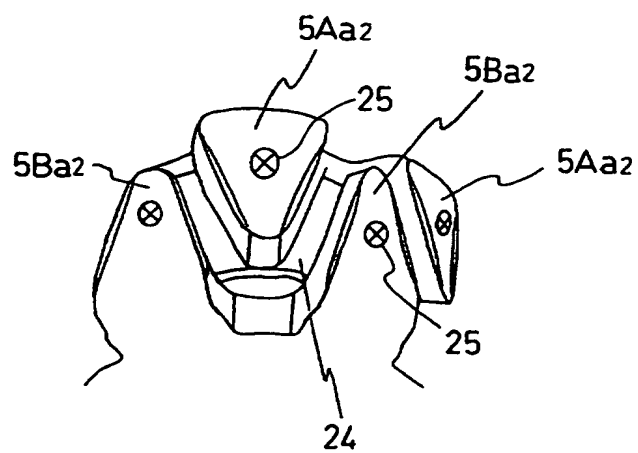
**FIG.5**



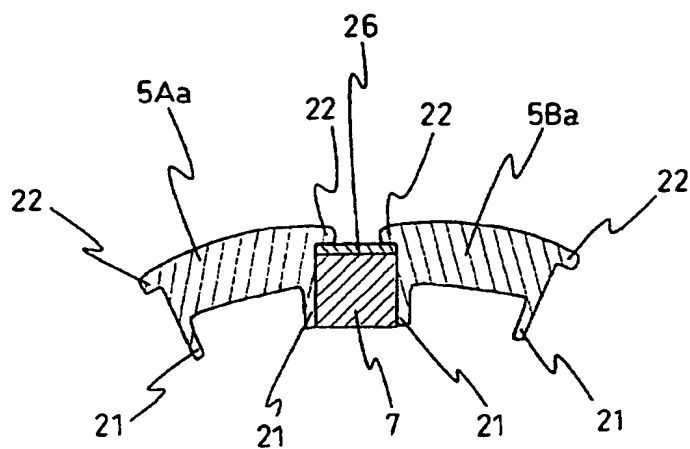
**FIG.6**



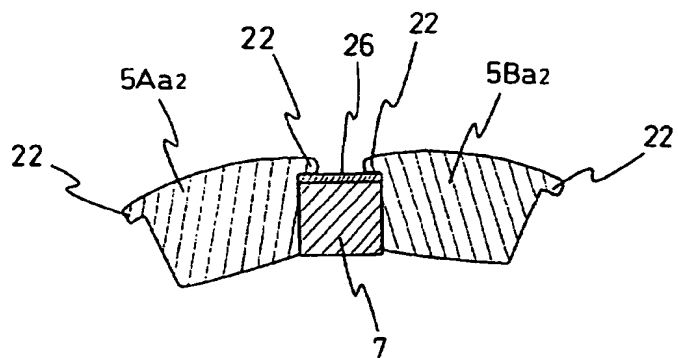
**FIG.7**



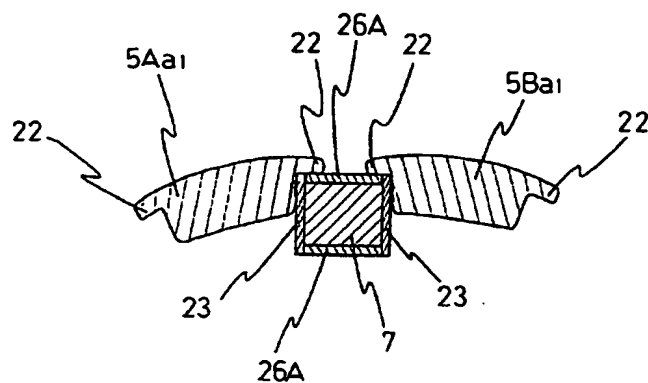
**FIG.8**



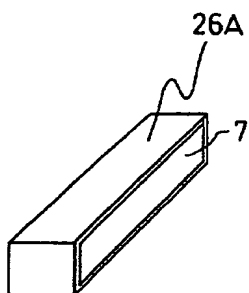
**FIG.9**



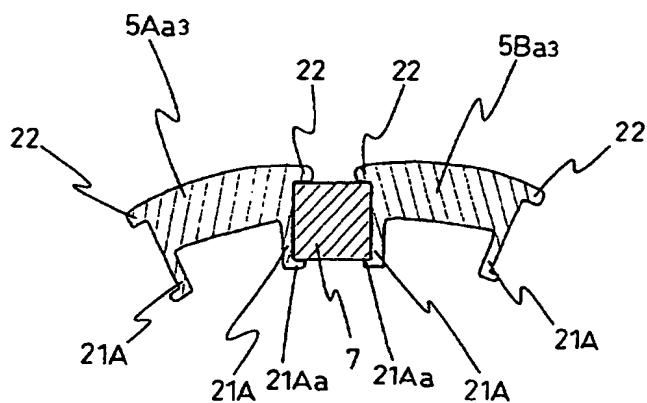
**FIG. 10**



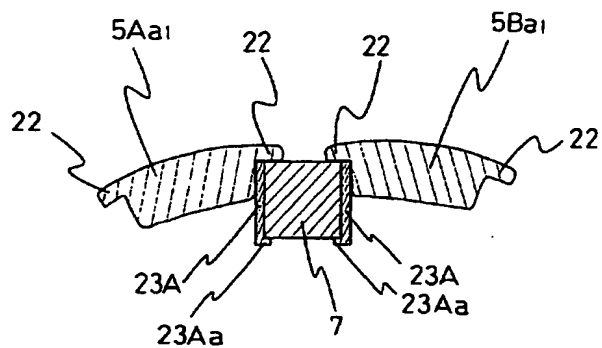
**FIG. 11**



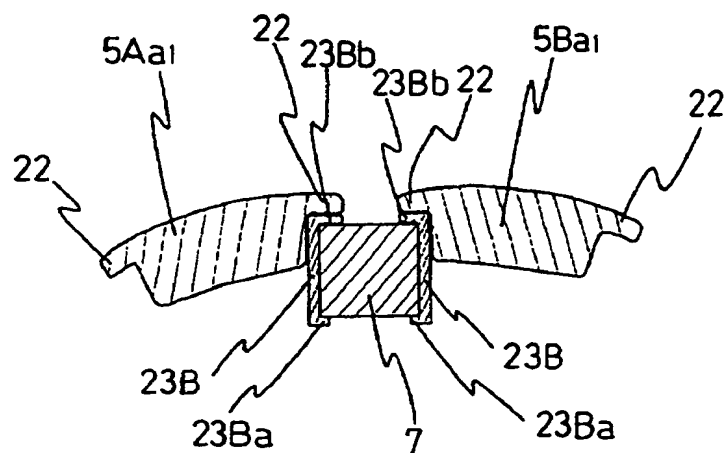
**FIG. 12**



**FIG. 13**



**FIG. 14**



## VEHICULAR ALTERNATOR

### BACKGROUND OF THE INVENTION

#### [0001] 1. Field of the Invention

[0002] The present invention relates to a vehicular alternator, and more particularly to a vehicular alternator including a permanent magnet for auxiliary excitation.

#### [0003] 2. Description of the Related Art

[0004] A vehicular alternator usually comprises a rotor and a stator. In general, the rotor comprises a pair of claw-type magnetic poles arranged in an opposed relation, and field windings coiled radially inward of a plurality of claws provided in each of the claw-type magnetic poles. When a current is supplied to the field windings, the pair of claw-type magnetic poles are magnetized to N and S poles. Also, the stator is constituted by coiling stator windings, from which an AC induced voltage is outputted, over a stator core. The rotor is rotated relative to the stator.

[0005] With such a structure, a magnetic circuit is formed in which the magnetic flux outgoing from the claw-type magnetic pole magnetized to an N pole returns to the claw-type magnetic pole magnetized to an S pole through the stator windings. The magnetic flux of the magnetic circuit is in an interlinkage relation to the stator windings of the stator, while the rotor rotates relative to the stator. As a result, an AC induced voltage is generated in the stator windings.

[0006] In the vehicular alternator having the above-described structure, efforts to reduce the magnetic flux leaked between the claw-type magnetic poles and to intensify the magnetic flux generated from the field windings for an increase in output of the alternator have been made, for example, by interposing a permanent magnet for auxiliary excitation between the claw-type magnetic poles. JP,A 11-318064, for example, discloses such a vehicular alternator including a permanent magnet for auxiliary excitation disposed between the claw-type magnetic poles.

[0007] The above-mentioned related art, however, has the following problem.

[0008] Usually, claws of a claw-type magnetic pole are each formed into a substantially triangular shape in section taken along the axial direction of a rotor such that the claw is tapered toward its tip, for the purpose of reducing the weight of a claw end portion. This is because the claws of the claw-type magnetic pole are cantilevered. In other words, such a sectional shape is intended to prevent the claw end portion from rising radially outward of the rotor due to centrifugal forces when the rotor rotates at high speeds. Therefore, when a permanent magnet having a relatively large thickness in the radial direction of the rotor is disposed between the adjacent claws of the claw-type magnetic poles, a part of each lateral surface (i.e., magnetic pole surface) of the permanent magnet in the circumferential direction of the rotor does not contact the claw, thus resulting in increased resistance against a flow of magnetic flux (i.e., greater magnetic loss) in a magnetic circuit formed by the permanent magnet. Accordingly, the magnetic flux of the permanent magnet is not effectively utilized.

[0009] In the above-described related art, each claw is likewise formed into a substantially triangular shape in

section taken along the axial direction of the rotor such that the claw is tapered toward its tip. Although the related art employs a permanent magnet having a relatively small thickness in the radial direction of the rotor, a particular consideration is not focused on the shape of a contact surface between the claw and the permanent magnet. Hence, a part of a magnetic pole surface of the permanent magnet not contacting the claw also occurs near a claw end portion, and effective utilization of the magnetic flux of the permanent magnet is not ensured.

### SUMMARY OF THE INVENTION

[0010] Accordingly, it is an object of the present invention to provide a vehicular alternator, which can effectively utilize the magnetic flux of a permanent magnet disposed between claw-type magnetic poles and can improve an output of the alternator.

[0011] (1) To achieve the above object, the present invention provides a vehicular alternator comprising a rotor and a stator constituted by coiling stator windings over a stator core, the rotor comprising a pair of claw-type magnetic poles arranged in an opposed relation, a permanent magnet disposed between adjacent two of a plurality of claws provided on the pair of claw-type magnetic poles, and field windings coiled radially inward of the plurality of claws, wherein each of the plurality of claws of the rotor is formed to have a shape coming into contact with the whole of the magnetic pole surface of the permanent magnet.

[0012] As described above in connection with the related art, claws of a claw-type magnetic pole are each usually formed into a substantially triangular shape in section taken along the axial direction of a rotor such that the claw is tapered toward its tip. Therefore, when a permanent magnet having a relatively large thickness in the radial direction of the rotor is disposed between the adjacent claws of the claw-type magnetic poles, a part of each lateral surface (magnetic pole surface) of the permanent magnet in the circumferential direction of the rotor does not contact the claw. Thus, the resistance against a flow of magnetic flux (i.e., magnetic loss) in a magnetic circuit formed by the permanent magnet is increased and the magnetic flux of the permanent magnet is not effectively utilized.

[0013] To overcome that problem, according to one aspect of the present invention, the claws of the claw-type magnetic poles are each formed to a shape coming into contact with the whole of the magnetic pole surface of the permanent magnet in the circumferential direction of the rotor. This feature enables almost all of the magnetic flux outgoing from the permanent magnet to flow into the claws, thus resulting in reduced resistance against a flow of the magnetic flux (i.e., smaller magnetic loss) in the magnetic circuit formed by the permanent magnet. As a result, the magnetic flux of the permanent magnet disposed between the adjacent claws of the claw-type magnetic poles can be effectively utilized, and the output of the vehicular alternator can be increased.

[0014] (2) In above (1), preferably, each of the plurality of claws has an auxiliary magnetic pole portion contacting the whole of the magnetic pole surface of the permanent magnet.

[0015] (3) In above (2), preferably, the auxiliary magnetic pole portion is formed to have a greater width on the outer side in the radial direction of the rotor than on the inner side in the radial direction of the rotor.

[0016] (4) In above (1), preferably, each of the plurality of claws is formed such that an inner surface of each claw in the radial direction of the rotor is substantially parallel to an outer surface thereof in the radial direction of the rotor.

[0017] (5) In above (4), preferably, the plurality of claws are interconnected by a substantially ring-shaped coupling member.

[0018] (6) In any of above (1) to (5), more preferably, each of the plurality of claws has a magnet holding portion for holding the permanent magnet.

[0019] (7) Also, to achieve the above object, the present invention provides a vehicular alternator comprising a rotor and a stator constituted by coiling stator windings over a stator core, the rotor comprising a pair of claw-type magnetic poles arranged in an opposed relation, a permanent magnet disposed between adjacent two of a plurality of claws provided on the pair of claw-type magnetic poles, and field windings coiled radially inward of the plurality of claws, wherein an auxiliary magnetic pole plate contacting the whole of a magnetic pole surface of the permanent magnet is interposed between each of the plurality of claws and the permanent magnet.

[0020] Thus, according to another aspect of the present invention, the auxiliary magnetic pole plate contacting the whole of a lateral surface (magnetic pole surface) of the permanent magnet in the circumferential direction of the rotor is interposed between each claw and the permanent magnet. This arrangement enables almost all of the magnetic flux outgoing from the permanent magnet to flow into the claws, thus resulting in reduced resistance against a flow of the magnetic flux (i.e., smaller magnetic loss) in the magnetic circuit formed by the permanent magnet. As a result, the magnetic flux of the permanent magnet disposed between the adjacent claws of the claw-type magnetic poles can be effectively utilized, and the output of the vehicular alternator can be increased.

[0021] (8) In above (7), preferably, the auxiliary magnetic pole plate has a magnet holding portion for holding the permanent magnet.

[0022] (9) In any of above (1) to (8), more preferably, a protective member is disposed at least on the outer side of the permanent magnet in the radial direction of the rotor.

#### BRIEF DESCRIPTION OF THE DRAWINGS

[0023] FIG. 1 is a sectional view showing an overall structure of a first embodiment of a vehicular alternator according to the present invention;

[0024] FIG. 2 is a side view showing a detailed structure of a claw provided in the first embodiment of the vehicular alternator according to the present invention;

[0025] FIG. 3 is a sectional view, taken along line III-III in FIG. 1, showing the positional relationship between

claws and a permanent magnet provided in the first embodiment of the vehicular alternator according to the present invention;

[0026] FIG. 4 is a partial enlarged view corresponding to a part A in FIG. 3, showing a structure of a modification in which an auxiliary magnetic pole portion provided in the vehicular alternator of the first embodiment according to the present invention is modified with intent to realize reinforcement of the strength, to promote a smooth flow of magnetic flux, and to reduce noise;

[0027] FIG. 5 is a sectional view corresponding to FIG. 3, showing the positional relationship between claws of claw-type magnetic poles and a permanent magnet provided in a second embodiment of the vehicular alternator according to the present invention;

[0028] FIG. 6 is a sectional view corresponding to FIG. 3, showing the positional relationship between claws of claw-type magnetic poles and a permanent magnet provided in a third embodiment of the vehicular alternator according to the present invention;

[0029] FIG. 7 is a perspective view showing a detailed structure of a modification of the third embodiment of the vehicular alternator according to the present invention, in which the claws are interconnected by a coupling ring;

[0030] FIG. 8 is a sectional view corresponding to FIG. 3, showing the positional relationship between claws of claw-type magnetic poles and a permanent magnet provided in a modification of the first embodiment of the vehicular alternator according to the present invention, in which a magnet cover is provided;

[0031] FIG. 9 is a sectional view corresponding to FIG. 6, showing the positional relationship between claws of claw-type magnetic poles and a permanent magnet provided in a modification of the third embodiment of the vehicular alternator according to the present invention, in which a magnet cover is provided;

[0032] FIG. 10 is a sectional view corresponding to FIG. 5, showing the positional relationship between claws of claw-type magnetic poles and a permanent magnet provided in a modification of the second embodiment of the vehicular alternator according to the present invention, in which a magnet cover is provided;

[0033] FIG. 11 is a perspective view showing an overall structure of the magnet cover shown in FIG. 10;

[0034] FIG. 12 is a sectional view corresponding to FIG. 3, showing the positional relationship between claws of claw-type magnetic poles and a permanent magnet provided in a modification of the first embodiment of the vehicular alternator according to the present invention, in which a magnet holding portion is provided;

[0035] FIG. 13 is a sectional view corresponding to FIG. 5, showing the positional relationship between claws of claw-type magnetic poles and a permanent magnet provided in a modification of the second embodiment of the vehicular alternator according to the present invention, in which a magnet holding portion is provided;

[0036] FIG. 14 is a sectional view corresponding to FIG. 5, showing the positional relationship between claws of claw-type magnetic poles and a permanent magnet provided



in another modification of the second embodiment of the vehicular alternator according to the present invention, in which a magnet holding portion is provided.

#### DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0037] Embodiments of the present invention will be described with reference to the drawings.

[0038] FIG. 1 is a sectional view showing an overall structure of a first embodiment of a vehicular alternator according to the present invention.

[0039] Referring to FIG. 1, the vehicular alternator of this embodiment mainly comprises a rotor 1 and a stator 2. The rotor 1 comprises a shaft (rotary shaft) 3; a yoke 4 having the center of rotation through which the shaft 3 is inserted; a pair of claw-type magnetic poles 5A, 5B each made of a magnetic substance and having the center of rotation through which the shaft 3 is inserted, the claw-type magnetic poles 5A, 5B being arranged in an opposed relation through the yoke 4 with a predetermined spacing held between them in the axial direction of the rotor 1 (left-and-right direction in FIG. 1); and field windings 6 coiled over the yoke 4.

[0040] The claw-type magnetic poles 5A, 5B are provided with a plurality of claws 5Aa, 5Ba, respectively. Looking in the circumferential direction of the rotor 1, as shown in FIG. 1, the claws 5Aa, 5Ba are disposed to project alternately in the axial direction of the rotor 1 (left-and-right direction in FIG. 1) in an overlapped relation. A permanent magnet 7 for auxiliary excitation is interposed between two adjacent claws 5Aa, 5Ba in the circumferential direction of the rotor 1. Further, the field windings 6 coiled over the yoke 4 are positioned inward of the claws 5Aa, 5Ba in the radial direction of the rotor 1 with a predetermined space gap left therebetween.

[0041] The shaft 3 is rotatably supported with respect to an alternator body, which comprises end brackets 8A, 8B, by a bearing 9A at a position near an end on one side (left side in FIG. 1) and a bearing 9B at a position near an end on the other side (right side in FIG. 1). Also, a pulley 10 is fixed by a bolt 11 to the end of the shaft 3 on one side (left side in FIG. 1), and slip rings 12a, 12b are provided near the end of the shaft 3 on the other side (right side in FIG. 1). Additionally, the pulley 10 is coupled by a belt or the like to, for example, a crank pulley of an engine (not shown).

[0042] Inside the end bracket 8B, brushes 13a, 13b are provided in slide contact with outer circumferences of the slip rings 12a, 12b. A current is supplied to the field windings 6 of the rotor 1 during rotation thereof through the brushes 13a, 13b and the slip rings 12a, 12b. By supplying a current to the field windings 6, the claw-type magnetic pole 5A of the rotor 1 is magnetized to an S pole and the claw-type magnetic pole 5B is magnetized to an N pole.

[0043] The stator 2 comprises a stator core 14 sandwiched between the end brackets 8A, 8B and positioned outward of the claws 5Aa, 5Ba in the radial direction of the rotor 1 (on the upper and lower sides in FIG. 1) with small gaps left relative to the claws 5Aa, 5Ba; and three-phase stator windings 15 coiled over the stator core 14 for outputting an AC induced voltage from them. The rotor 1 is rotated relative to the stator 2. With the stator 2 having the above-described structure, a magnetic circuit is formed in which

the magnetic flux outgoing from the claw-type magnetic pole 5B magnetized to an N pole returns to the claw-type magnetic pole 5A magnetized to an S pole through the stator core 14. The magnetic flux of the magnetic circuit is in an interlinkage relation to the stator windings 15, while the rotor 1 rotates relative to the stator 2. As a result, an AC induced voltage is generated in the stator windings 15.

[0044] A rectifying circuit 16 and a voltage adjuster 17 are provided inside the end bracket 8B. The rectifying circuit 16 has a battery terminal 18 connected to a positive electrode of a battery (not shown) and a grounding terminal 19 connected to a negative electrode of the battery (not shown). The rectifying circuit 16 rectifies the AC induced voltage, which is generated in the stator windings 15 as described above, for conversion into a DC voltage. The voltage adjuster 17 controls the current supplied to the field windings 6 depending on a load current and the number of revolutions of the rotor 1 so that the DC voltage rectified by the rectifying circuit 16 is kept at a constant voltage of, e.g., about 14.5 V, for thereby charging the battery (not shown).

[0045] Cooling fans 20a, 20b for air-cooling the stator 2 and the rectifying circuit 16 are provided on both sides of the rotor 1 in the axial direction thereof (left-and-right direction in FIG. 1). The cooling fans 20a, 20b produces cooling air at a flow rate in proportion to the number of revolutions of the rotor 1.

[0046] In this embodiment thus constructed, the most important feature of the present invention resides in that the claws 5Aa, 5Ba of the rotor 1 are each formed to have a shape coming into contact with the whole of the lateral surface (i.e., magnetic pole surface) of the permanent magnet 7 in the circumferential direction of the rotor 1.

[0047] FIG. 2 is a side view showing a detailed structure of the claw 5Aa, and FIG. 3 is a sectional view, taken along line III-III in FIG. 1, showing the positional relationship between the claws 5Aa, 5Ba and the permanent magnet 7. For the sake of brevity, FIG. 3 shows only one pole constituted by each of the claws 5Aa, 5Ba.

[0048] More specifically, as shown in FIGS. 2 and 3, the claws 5Aa, 5Ba are each formed into a substantially triangular shape in section taken along the axial direction of the rotor 1 (left-and-right direction in FIG. 2), as indicated by dotted line in FIG. 2 similarly to the related art, such that the claw 5Aa, for example, is tapered toward its tip (to the right in FIG. 2), except for both lateral ends of each claw in the circumferential direction of the rotor 1. The permanent magnet 7 is formed to have substantially rectangular lateral surfaces (i.e., magnetic pole surfaces) in the circumferential direction of the rotor 1 (left-and-right direction in FIG. 3). Then, as described above, the permanent magnet 7 is interposed between the claws 5Aa, 5Ba overlapping with each other in the axial direction of the rotor 1 (left-and-right direction in FIG. 2).

[0049] In addition, auxiliary magnetic pole portions 21 are provided at both the lateral ends of each of the claws 5Aa, 5Ba (end surfaces of the claws 5Aa, 5Ba facing each other in an overlapped relation) in the circumferential direction of the rotor 1 (left-and-right direction in FIG. 3) so as to project inward for contact with the whole of the magnetic pole surfaces of the permanent magnet 7. In this embodiment, each auxiliary magnetic pole portion 21 is formed into

substantially the same shape as the corresponding magnetic pole surface of the permanent magnet 7 so that the auxiliary magnetic pole portion 21 is brought into close contact with the permanent magnet 7. Further, projecting flanges 22 are provided at both the lateral ends of each of the claws 5Aa, 5Ba in the circumferential direction of the rotor 1 (left-and-right direction in FIG. 3) so as to project circumferentially from outermost portions of both the lateral ends of each claw in the radial direction of the rotor 1 (upper side in FIG. 3). The flanges 22 serve to prevent the permanent magnet 7 from ejecting outward due to the rotation of the rotor 1.

[0050] The operation of the thus-constructed vehicular alternator of this embodiment will be described below.

[0051] First, a current is supplied through the brushes 13a, 13b and the slip rings 12a, 12b to the field windings 6 of the rotor 1 that is rotated upon receiving motive power from, e.g., the engine (not shown). With the supply of a current, as described above, the claw-type magnetic pole 5A of the rotor 1 is magnetized to an S pole and the claw-type magnetic pole 5B is magnetized to an N pole. A magnetic circuit is thereby formed in which the magnetic flux outgoing from the claw-type magnetic pole 5B magnetized to an N pole returns to the claw-type magnetic pole 5A magnetized to an S pole through the stator core 14 in the stator 2. At that time, the magnetic flux of the magnetic circuit formed by the field windings 6 is intensified by addition of the magnetic flux of the permanent magnet 7 for auxiliary magnetization. Furthermore, the magnetic flux of the magnetic circuit is in an interlinkage relation to the stator windings 15. As a result, with the rotation of the rotor 1 an AC induced voltage is generated in the 3-phase stator windings 15 coiled over the stator core 14.

[0052] The generated voltage is rectified by the rectifying circuit 16 for conversion into a DC voltage, and then finally charged in the battery (not shown). For charging the battery (not shown) with the DC voltage rectified by the rectifying circuit 16, the voltage adjuster 17 controls the current supplied to the field windings 6 depending on a load current and the number of revolutions of the rotor 1 so that the generated voltage is kept at a constant voltage of, e.g., about 14.5 V.

[0053] Advantages obtainable with the operation of this embodiment will be described below.

#### [0054] (1) Higher Output

[0055] Usually, claws of a claw-type magnetic pole are each formed into a substantially triangular shape in section taken along the axial direction of a rotor such that the claw is tapered toward its tip. Therefore, when a permanent magnet having a relatively large thickness in the radial direction of the rotor is disposed between the adjacent claws of the claw-type magnetic poles, a part of each magnetic pole surface of the permanent magnet does not contact the claw. Thus, the resistance against a flow of magnetic flux (i.e., magnetic loss) in a magnetic circuit formed by the permanent magnet is increased and the magnetic flux of the permanent magnet is not effectively utilized.

[0056] To cope with that problem, in this embodiment, the claws 5Aa, 5Ba of the claw-type magnetic poles 5A, 5B are each formed to have a shape coming into contact with the whole of the magnetic pole surface of the permanent magnet 7 in the circumferential direction of the rotor 1, thereby

enabling almost all of the magnetic flux outgoing from the permanent magnet 7 to flow into the claws 5Aa, 5Ba. It is hence possible to reduce the resistance against a flow of the magnetic flux (i.e., magnetic loss) in the magnetic circuit formed by the permanent magnet 7 and to effectively utilize the magnetic flux of the permanent magnet. As a result, the output of the vehicular alternator can be increased.

#### [0057] (2) Lower Cost

[0058] Also, in this embodiment, even in the case of reducing the size of the permanent magnet 7, the magnetic flux of the permanent magnet 7 can be effectively utilized and the output of the vehicular alternator can be increased because of the advantage of above (1). Consequently, the production cost of the vehicular alternator can be reduced.

#### [0059] (3) Restraint of Demagnetization at High-Temperatures

[0060] For example, a neodymium magnet is employed as the permanent magnet for auxiliary excitation. The inflection point of an irreversible demagnetization characteristic of such a permanent magnet varies when temperature rises. If the permeance factor is low, therefore, the magnetic density may reduce at high temperatures (called demagnetization at high temperatures). In such a case, when the conventional claw-type magnetic pole is employed which has the claw not contacting the whole of the magnetic pole surface of the permanent magnet, the resistance against a flow of the magnetic flux is increased in the part of the magnetic pole surface of the permanent magnet not contacting the claw of the claw-type magnetic pole, and hence the permeance factor is partly lowered.

[0061] Comparing a working point of a permanent magnet having both magnetic poles not in contact with a magnetic substance and a working point of a permanent magnet having both magnetic poles in contact with a magnetic substance, the latter permanent magnet having both magnetic poles in contact with a magnetic substance has a higher magnetic density at the working point because the permeance factor is higher at the working point thereof. In this embodiment, since both the magnetic poles of the permanent magnet 7 are entirely held in contact with the claws 5Aa, 5Ba (exactly speaking, the auxiliary magnetic pole portions 21) of the claw-type magnetic poles 5A, 5B, the effect of the demagnetization at high temperatures can be minimized and an allowance of the permanent magnet 7 for compensating the demagnetization at high temperatures can be increased.

#### [0062] (4) Easier Magnetization of Permanent Magnet

[0063] For the purpose of preventing metal dust, such as iron powder, from adhering to the permanent magnet, a process of manufacturing the vehicular alternator generally comprises the steps of arranging each permanent magnet for auxiliary excitation, which is in a not yet magnetized state, between the adjacent claws of the claw-type magnetic poles, adjusting a balance in rotation of a rotor, and magnetizing the permanent magnet through an external magnetizing yoke (not shown), for example, in a final stage of the process for manufacturing the rotor. When applying such a manufacturing process to the vehicular alternator of this embodiment, since both the lateral surfaces of the permanent magnet 7 in the circumferential direction of the rotor 1 are entirely held in contact with the claws 5Aa, 5Ba (exactly speaking, the auxiliary magnetic pole portions 21) of the

claw-type magnetic poles 5A, 5B, magnetic flux can be sufficiently permeated to the permanent magnet 7 in the not yet magnetized state, and hence the operation of magnetizing the permanent magnet 7 can be facilitated.

[0064] In this embodiment described above, as shown in FIG. 3, the auxiliary magnetic pole portion 21 provided on each of the claws 5Aa, 5Ba is formed to have a substantially uniform thickness (width in the left-and-right direction in FIG. 3). However, the auxiliary magnetic pole portion 21 may be modified as shown in FIG. 4. Specifically, an auxiliary magnetic pole portion 21' shown in FIG. 4 has a width W2 on the proximal side (on the upper side in FIG. 4, i.e., the outer side in the radial direction of the rotor 1) slightly thicker than a width W1 on the distal side (on the lower side in FIG. 4, i.e., the inner side in the radial direction of the rotor 1). The auxiliary magnetic pole portion 21' having such a shape contributes to increasing the mechanical strength of the auxiliary magnetic pole portion itself and smoothing a flow of the magnetic flux incoming from the permanent magnet 7.

[0065] Further, in the modification of FIG. 4, the flange 22 is replaced by a flange 22' that is beveled at its outermost corner. The beveled flange 22' makes smoother magnetic coupling and decoupling between the claws 5Aa, 5Ba and the stator core 14 during the rotation of the rotor 1. Accordingly, pulsations of the magnetic flux in the space gaps between the stator 2 and the claws 5Aa, 5Ba are reduced. It is hence possible to suppress magnetic vibration and reduce noise.

[0066] Note that FIG. 4 is a partial enlarged view showing a detailed structure of the modification corresponding to a part A in FIG. 3 of the first embodiment.

[0067] A second embodiment of the vehicular alternator of the present invention will be described below with reference to FIG. 5.

[0068] FIG. 5 is a sectional view corresponding to FIG. 3, showing the positional relationship between claws 5Aa<sub>1</sub>, 5Ba<sub>1</sub> of the claw-type magnetic poles 5A, 5B and the permanent magnet 7 provided in the second embodiment of the vehicular alternator according to the present invention. In FIG. 5, similar components to those in FIG. 3 are denoted by the same reference characters and a description thereof is omitted herein. In the following description, other drawings are also referred to, as an occasion requires. For the sake of brevity, FIG. 5 shows only one pole constituted by each of the claws 5Aa<sub>1</sub>, 5Ba<sub>1</sub>, as with FIG. 3.

[0069] Though not specifically shown for the sake of brevity, the claws 5Aa<sub>1</sub>, 5Ba<sub>1</sub> are each formed into a substantially triangular shape in section taken along the axial direction of the rotor 1 (direction perpendicular to the drawing sheet of FIG. 5) such that the claw is tapered toward its tip, similarly to the related art, except for the flanges 22. In this embodiment, as shown in FIG. 5, an auxiliary magnetic pole plate 23 made of a magnetic substance is interposed between each of the claws 5Aa<sub>1</sub>, 5Ba<sub>1</sub> having the shape described above and the permanent magnet 7 such that the plate 23 contacts the whole of a corresponding magnetic pole surface of the permanent magnet 7. The remaining construction is the same as that of the first embodiment.

[0070] Thus, in this embodiment, since the auxiliary magnetic pole plate 23 contacting the whole of the magnetic pole

surface of the permanent magnet 7 is interposed between each of the claws 5Aa<sub>1</sub>, 5Ba<sub>1</sub> and the permanent magnet 7, almost all of the magnetic flux outgoing from the permanent magnet 7 is rendered to flow into the claw-type magnetic poles 5A, 5B through the auxiliary magnetic pole plates 23. It is hence possible to reduce the resistance against a flow of the magnetic flux (i.e., magnetic loss) in the magnetic circuit formed by the permanent magnet 7. As with the first embodiment, therefore, the magnetic flux of the permanent magnet 7 disposed between the adjacent claws 5Aa<sub>1</sub>, 5Ba<sub>1</sub> of the claw-type magnetic poles 5A, 5B can be effectively utilized, and the output of the vehicular alternator can be increased.

[0071] When magnetizing the permanent magnet 7 in this embodiment, the auxiliary magnetic pole plates 23 are previously bonded to the surfaces (both left and right side surfaces in FIG. 5) of the permanent magnet 7, which are to be magnetized. The permanent magnet 7 including the auxiliary magnetic pole plates 23 is disposed between two adjacent claws 5Aa<sub>1</sub>, 5Ba<sub>1</sub>, and then magnetized through an external magnetizing yoke (not shown). As described above, the permanent magnet 7 is preferably magnetized in a final stage of the process for manufacturing the rotor 1 after attaching the cooling fans 20a, 20b (see FIG. 1) and adjusting a balance in rotation of the rotor. By employing such a magnetizing process, it is possible to prevent metal dust, such as iron powder, from adhering to the permanent magnet, and to realize a vehicular alternator with high reliability.

[0072] A third embodiment of the vehicular alternator of the present invention will be described below with reference to FIG. 6.

[0073] FIG. 6 is a sectional view corresponding to FIG. 3, showing the positional relationship between claws 5Aa<sub>2</sub>, 5Ba<sub>2</sub> of the claw-type magnetic poles 5A, 5B and the permanent magnet 7 provided in the third embodiment of the vehicular alternator according to the present invention. In FIG. 6, similar components to those in FIG. 3 are denoted by the same reference characters and a description thereof is omitted herein. In the following description, other drawings are also referred to, as an occasion requires. For the sake of brevity, FIG. 6 shows only one pole constituted by each of the claws 5Aa<sub>2</sub>, 5Ba<sub>2</sub> as with FIG. 3.

[0074] In this embodiment, the claws 5Aa<sub>2</sub>, 5Ba<sub>2</sub> are each formed such that an inner surface (lower side in FIG. 6) of each claw in the radial direction of the rotor 1 is substantially parallel to an outer surface (upper side in FIG. 6) thereof in the radial direction of the rotor 1. In other words, though not specifically shown for the sake of brevity, each of the claws 5Aa<sub>2</sub>, 5Ba<sub>2</sub> is formed to have a thickness substantially uniform throughout from the distal end to the proximal end, and hence to have a substantially rectangular shape in section taken along the axial direction of the rotor 1 (direction perpendicular to the drawing sheet of FIG. 6).

[0075] Because of the claws 5Aa<sub>2</sub>, 5Ba<sub>2</sub> having such a structure, both the lateral surfaces (magnetic pole surfaces) of the permanent magnet 7 in the circumferential direction (left-and-right direction in FIG. 6) of the rotor 1 are entirely held in close contact with the claws 5Aa<sub>1</sub>, 5Ba<sub>1</sub> made of a magnetic substance. The remaining construction is the same as that of the first embodiment. Accordingly, this embodiment can also provide similar advantages to those in the first embodiment.

[0076] Moreover, this embodiment is particularly suitable for a vehicular alternator used in, e.g., construction machines or the likes. Since the claws  $5Aa_2$ ,  $5Ba_2$  are each formed to have a thickness substantially uniform throughout from the distal end to the proximal end, the distal end of each claw  $5Aa_2$ ,  $5Ba_2$  has greater weight than those of the claws  $5Aa_1$ ,  $5Ba_1$  used in the first and second embodiments. Hence, there is a possibility in this embodiment that the claw distal end may rise outward (upward in FIG. 6) due to the rotation of the rotor 1 (see FIG. 1). In general, however, a vehicular alternator used in, e.g., construction machines or the likes rotates at constant speed with the relatively small number of revolutions in the range of 3000 to 4000 rpm. Therefore, the stresses acting upon root portions of the claws  $5Aa_2$ ,  $5Ba_2$  attributable to centrifugal forces are relatively small, thus resulting in a small possibility that the distal ends of the claws  $5Aa_2$ ,  $5Ba_2$  rise as mentioned above. On the other hand, the claws  $5Aa_2$ ,  $5Ba_2$  each having the above-described shape in this embodiment enable the magnetic flux smoothly to flow into each claw from the permanent magnet 7. This embodiment is hence suitable for the vehicular alternator used in, e.g., construction machines or the likes, which is required to have a higher output.

[0077] Furthermore, in the case of rotating the vehicular alternator of this third embodiment at high speeds, the claws  $5Aa_2$ ,  $5Ba_2$  may be interconnected by a coupling ring 24, which is substantially in the form of a ring and fitted to the claws from the inner side in the radial direction of the rotor 1. The coupling ring 24 is fixed to each of the claws  $5Aa_2$ ,  $5Ba_2$  by a screw 25 (the fixing method is not limited to the use of screws, and the coupling ring 24 may be fixed by welding, for example). In such a modification, it is desired that the coupling ring 24 is made of a nonmagnetic substance and the screw 25 is made of a magnetic substance. For the sake of brevity, the permanent magnet 7 is omitted from FIG. 7. Additionally, the coupling ring 24 constitutes a substantially ring-shaped coupling member set forth in claim 5.

[0078] A magnet cover may be disposed as a protective member at least on the outer side of the permanent magnet 7 in the radial direction of the rotor 1. The magnetic cover serves to prevent fragments of the permanent magnet 7 from ejecting outward of the rotor 1 due to the rotation of the rotor 1 in the event the permanent magnet 7 is broken for some reason.

[0079] Several modifications, in which a magnetic cover is provided in the vehicular alternator of the present invention, will be described below one by one.

[0080] FIG. 8 is a sectional view corresponding to FIG. 3, showing the positional relationship between the claws  $5Aa$ ,  $5Ba$  of the claw-type magnetic poles 5A, 5B and the permanent magnet 7 provided in a modification of the above-described first embodiment of the vehicular alternator according to the present invention, in which a magnet cover is provided. In FIG. 8, similar components to those in FIG. 3 are denoted by the same reference characters and a description thereof is omitted herein. In the following description, other drawings are also referred to, as an occasion requires. For the sake of brevity, FIG. 8 shows only one pole constituted by each of the claws  $5Aa$ ,  $5Ba$  as with FIG. 3.

[0081] Referring to FIG. 8, an outer surface of the permanent magnet 7 in the radial direction of the rotor 1 closely contacts a magnetic cover 26 having substantially the same rectangular shape as the outer surface of the permanent magnet 7. The magnetic cover 26 is preferably made of a nonmagnetic substance having superior rust resistance, such as stainless steel, so that the magnetic flux of the permanent magnet 7 disposed between the adjacent claws  $5Aa$ ,  $5Ba$  of the claw-type magnetic poles 5A, 5B acts effectively. In this modification, the magnetic cover 26 is retained in place by the flanges 22. While the magnetic cover 26 is provided in this modification, both the magnetic pole surfaces of the permanent magnet 7 are entirely held in contact with the claws  $5Aa$ ,  $5Ba$  (exactly speaking, the auxiliary magnetic pole portions 21) of the claw-type magnetic poles 5A, 5B.

[0082] FIG. 9 is a sectional view corresponding to FIG. 6, showing the positional relationship between the claws  $5Aa_2$ ,  $5Ba_2$  of the claw-type magnetic poles 5A, 5B and the permanent magnet 7 provided in a modification of the above-described third embodiment of the vehicular alternator according to the present invention, in which a magnet cover is provided. In FIG. 9, similar components to those in FIG. 6 are denoted by the same reference characters and a description thereof is omitted herein. In the following description, other drawings are also referred to, as an occasion requires. For the sake of brevity, FIG. 9 shows only one pole constituted by each of the claws  $5Aa_2$ ,  $5Ba_2$  as with FIG. 6.

[0083] Referring to FIG. 9, as with the modification described above with reference to FIG. 8, an outer surface of the permanent magnet 7 in the radial direction of the rotor 1 closely contacts a magnetic cover 26 having substantially the same rectangular shape as the outer surface of the permanent magnet 7. Preferably, the magnetic cover 26 is made of a nonmagnetic substance having superior rust resistance, e.g., stainless steel, so that the magnetic flux of the permanent magnet 7 disposed between the adjacent claws  $5Aa_2$ ,  $5Ba_2$  of the claw-type magnetic poles 5A, 5B acts effectively. In this modification, the magnetic cover 26 is likewise retained in place by the flanges 22. While the magnetic cover 26 is provided in this modification, both the magnetic pole surfaces of the permanent magnet 7 are entirely held in contact with the claw-type magnetic poles 5A, 5B (exactly speaking, the claws  $5Aa_2$ ,  $5Ba_2$ ).

[0084] This modification is also adaptable for the case of rotating the rotor 1 at high speeds by interconnecting the claws  $5Aa_2$ ,  $5Ba_2$  by the coupling ring 24 described above with reference to FIG. 7.

[0085] With the above two modifications, in addition to the similar advantages to those in the first embodiment, another advantage can be obtained in preventing fragments of the broken permanent magnet 7 from ejecting outward of the rotor 1 due to the rotation of the rotor 1 in the event the permanent magnet 7 is broken for some reason.

[0086] When magnetizing the permanent magnet 7 in the above two modifications, the magnetic cover 26 is bonded to the outer surface of the permanent magnet 7 in the radial direction of the rotor 1 beforehand. The permanent magnet 7 including the magnetic cover 26 is disposed between the adjacent claws of the claw-type magnetic poles 5A, 5B, and then magnetized through an external magnetizing yoke (not shown). As described above, the permanent magnet 7 is

preferably magnetized in a final stage of the process for manufacturing the rotor 1. By employing such a magnetizing process, it is possible to prevent metal dust, such as iron powder, from adhering to the permanent magnet, and to realize a vehicular alternator with high reliability.

[0087] While each of the above two modifications has a structure that the outer surface of the permanent magnet 7 in the radial direction of the rotor 1 is protected by the magnetic cover 26 in the form of a plate, the present invention is not limited to such a structure. Because surfaces of the permanent magnet 7 other than the magnetic pole surfaces thereof impose no effects upon the magnetic characteristics, the magnetic cover may have, for example, a shape surrounding surfaces of the permanent magnet 7 other than the magnetic pole surfaces thereof. In other words, the magnetic cover may have various shapes within the scope not departing from the technical concept of the magnetic cover. A description is now made of modifications of the vehicular alternator according to the present invention, in which a magnetic cover is provided to surround four surfaces of the permanent magnet 7 other than the magnetic pole surfaces thereof, with reference to FIGS. 10 and 11.

[0088] FIG. 10 is a sectional view corresponding to FIG. 5, showing the positional relationship between the claws 5Aa<sub>1</sub>, 5Ba<sub>1</sub> of the claw-type magnetic poles 5A, 5B and the permanent magnet 7 provided in a modification of the above-described second embodiment of the vehicular alternator according to the present invention, in which a magnet cover is provided. FIG. 11 is a perspective view showing an overall structure of the magnet cover shown in FIG. 10. In FIG. 10, similar components to those in FIG. 5 are denoted by the same reference characters and a description thereof is omitted herein. In the following description, other drawings are also referred to, as an occasion requires. For the sake of brevity, FIG. 10 shows only one pole constituted by each of the claws 5Aa<sub>1</sub>, 5Ba<sub>1</sub> as with FIG. 5.

[0089] As shown in FIGS. 10 and 11, a magnetic cover 26A has a frame-like shape surrounding the four surfaces of the permanent magnet 7 other than the magnetic pole surfaces thereof. Inner peripheral wall surfaces of the magnetic cover 26A are finished with such a high degree of accuracy as enabling those wall surfaces to come into a very close contact with the four surfaces of the permanent magnet 7 other than the magnetic pole surfaces thereof. Preferably, the magnetic cover 26A is also made of a nonmagnetic substance having superior rust resistance, e.g., stainless steel, so that the magnetic flux of the permanent magnet 7 disposed between the adjacent claws 5Aa<sub>1</sub>, 5Ba<sub>1</sub> of the claw-type magnetic poles 5A, 5B acts effectively. In this modification, the magnetic cover 26A is likewise retained in place by the flanges 22. While the magnetic cover 26A is provided in this modification, both the magnetic pole surfaces of the permanent magnet 7 are entirely held in contact with the claws 5Aa<sub>1</sub>, 5Ba<sub>1</sub> of the claw-type magnetic poles 5A, 5B (exactly speaking, the auxiliary magnetic pole plates 23).

[0090] With this modification, in addition to the similar advantages to those in the first embodiment, another advantage can also be obtained in preventing fragments of the broken permanent magnet 7 from ejecting outward of the rotor 1 due to the rotation of the rotor 1 in the event the permanent magnet 7 is broken for some reason.

[0091] When magnetizing the permanent magnet 7 in this modification, the permanent magnet 7 in a not yet magnetized state is first inserted in the magnetic cover 26A such that it closely contacts the inner peripheral wall surfaces of the magnetic cover 26A. Then, in that condition, the two auxiliary magnetic pole plates 23 are arranged to position on the magnetic pole surfaces of the permanent magnet 7. As seen from FIG. 10, each of the auxiliary magnetic pole plates 23 has substantially the same dimensions as a lateral surface of the magnetic cover 26A in the circumferential direction (left-and-right direction in FIG. 10) of the rotor 1. The auxiliary magnetic pole plates 23 are fixedly joined to the magnetic cover 26A by, e.g., welding to form a box, and the permanent magnet 7 is held in close contact with inner wall surfaces of the box.

[0092] After assembling the magnetic cover 26A, the two auxiliary magnetic pole plates 23, and the permanent magnet 7 into an integral unit as described above, the unit is disposed between the adjacent claws 5Aa<sub>1</sub>, 5Ba<sub>1</sub> of the claw-type magnetic poles 5A, 5B such that the auxiliary magnetic pole plates 23 closely contact the claws 5Aa<sub>1</sub>, 5Ba<sub>1</sub>. The permanent magnet 7 is then magnetized through an external magnetizing yoke (not shown). As described above, the permanent magnet 7 is preferably magnetized in a final stage of the process for manufacturing the rotor 1. By employing such a magnetizing process, it is possible to prevent metal dust, such as iron powder, from adhering to the permanent magnet, and to realize a vehicular alternator with high reliability.

[0093] In the above three modifications, the magnetic covers 26, 26A each constitute a protective member set forth in claim 9.

[0094] As a matter of course, the magnetic covers 26, 26A may be optionally combined with any of the first to third embodiments described above.

[0095] Moreover, by providing a magnetic holding portion, which serves to mechanically hold the permanent magnet, on a part contacting the permanent magnet, such as the lateral surface of the claw in the circumferential direction of the rotor, the auxiliary magnetic pole portion and the auxiliary magnetic pole plate, the permanent magnet in a not yet magnetized state can be prevented from slipping off from the position between the claws of the claw-type magnetic poles, thus resulting in an improvement of the efficiency in works of, for example, assembling the rotor and magnetizing the permanent magnet.

[0096] Several modifications, in which a magnet holding portion is provided in the vehicular alternator of the present invention, will be described below one by one.

[0097] FIG. 12 is a sectional view corresponding to FIG. 3, showing the positional relationship between claws 5Aa<sub>3</sub>, 5Ba<sub>3</sub> of the claw-type magnetic poles 5A, 5B and the permanent magnet 7 provided in a modification of the above-described first embodiment of the vehicular alternator according to the present invention, in which a magnet holding portion is provided. In FIG. 12, similar components to those in FIG. 3 are denoted by the same reference characters and a description thereof is omitted herein. In the following description, other drawings are also referred to, as an occasion requires. For the sake of brevity, FIG. 12 shows only one pole constituted by each of the claws 5Aa<sub>3</sub>, 5Ba<sub>3</sub> as with FIG. 3.

[0098] In this modification, as shown in FIG. 12, a magnet holding portion 21Aa is provided at an inner end (on the lower side in FIG. 12) of each of auxiliary magnetic pole portions 21A in the radial direction of the rotor 1 so as to grip the permanent magnet 7 between the magnet holding portion 21Aa and the flange 22. While the magnet holding portions 21Aa are provided in this modification, both the magnetic pole surfaces of the permanent magnet 7 are entirely held in contact with the claws 5Aa<sub>1</sub>, 5Ba<sub>1</sub> of the claw-type magnetic poles 5A, 5B (exactly speaking, the auxiliary magnetic pole portions 21A). The remaining construction is the same as that of the first embodiment. It is needless to say that the magnet holding portion 21Aa is also applicable to the third embodiment.

[0099] FIG. 13 is a sectional view corresponding to FIG. 5, showing the positional relationship between the claws 5Aa<sub>1</sub>, 5Ba<sub>1</sub> of the claw-type magnetic poles 5A, 5B and the permanent magnet 7 provided in a modification of the above-described second embodiment of the vehicular alternator according to the present invention, in which a magnet holding portion is provided. In FIG. 13, similar components to those in FIG. 5 are denoted by the same reference characters and a description thereof is omitted herein. In the following description, other drawings are also referred to, as an occasion requires. For the sake of brevity, FIG. 13 shows only one pole constituted by each of the claws 5Aa<sub>1</sub>, 5Ba<sub>1</sub> as with FIG. 5.

[0100] In this modification, as shown in FIG. 13, a magnet holding portion 23Aa is provided at an inner end (on the lower side in FIG. 13) of each of auxiliary magnetic pole plates 23A in the radial direction of the rotor 1 so as to grip the permanent magnet 7 between the magnet holding portion 23Aa and the flange 22. While the magnet holding portions 23Aa are provided in this modification, both the magnetic pole surfaces of the permanent magnet 7 are entirely held in contact with the auxiliary magnetic pole plates 23A. The remaining construction is the same as that of the second embodiment.

[0101] FIG. 14 is a sectional view corresponding to FIG. 5, showing the positional relationship between the claws 5Aa<sub>1</sub>, 5Ba<sub>1</sub> of the claw-type magnetic poles 5A, 5B and the permanent magnet 7 provided in another modification of the above-described second embodiment of the vehicular alternator according to the present invention, in which a magnet holding portion is provided. In FIG. 14, similar components to those in FIG. 5 are denoted by the same reference characters and a description thereof is omitted herein. In the following description, other drawings are also referred to, as an occasion requires. For the sake of brevity, FIG. 14 shows only one pole constituted by each of the claws 5Aa<sub>1</sub>, 5Ba<sub>1</sub> as with FIG. 5.

[0102] In this modification, as shown in FIG. 14, magnet holding portions 23Ba, 23Bb are provided respectively at an inner end (on the lower side in FIG. 14) and outer end (on the upper side in FIG. 14) of each of auxiliary magnetic pole plates 23B in the radial direction of the rotor 1 so as to grip the permanent magnet 7 between them. While the magnet holding portions 23Ba, 23Bb are provided in this modification, both the magnetic pole surfaces of the permanent magnet 7 are entirely held in contact with the auxiliary magnetic pole plates 23B. The remaining construction is the same as that of the second embodiment.

[0103] When magnetizing the permanent magnet 7 in the two modifications described above with reference to FIGS. 13 and 14, the auxiliary magnetic pole plates 23A or 23B are previously bonded to the surfaces of the permanent magnet 7 (both the left and right lateral surfaces in FIGS. 13 and 14), which are to be magnetized. The permanent magnet 7 including the auxiliary magnetic pole plates is disposed between the adjacent claws 5Aa<sub>1</sub>, 5Ba<sub>1</sub> of the claw-type magnetic poles 5A, 5B, and then magnetized through an external magnetizing yoke (not shown). As described above, the permanent magnet 7 is preferably magnetized in a final stage of the process for manufacturing the rotor 1. By employing such a magnetizing process, it is possible to prevent metal dust, such as iron powder, from adhering to the permanent magnet, and to realize a vehicular alternator with high reliability. In the modification shown in FIG. 14, particularly, the work efficiency is improved because the auxiliary magnetic pole plate 23B has substantially the same shape in a vertical section as viewed in FIG. 14. Thus, that shape of the auxiliary magnetic pole plate 23B eliminates the necessity of due care for checking which side is above when assembling the permanent magnet 7 including the auxiliary magnetic pole plates 23B, which have been bonded to the magnetized surfaces of the permanent magnet 7, between the adjacent claws 5Aa<sub>1</sub>, 5Ba<sub>1</sub> of the claw-type magnetic poles 5A, 5B.

[0104] With the above three modifications, in addition to the similar advantages to those in the first embodiment, other advantages are obtained in that the permanent magnet 7 in a not yet magnetized state can be prevented from slipping off from the position between the claws of the claw-type magnetic poles 5A, 5B toward the side of the field windings 6, and the efficiency in works of, for example, assembling the rotor 1 and magnetizing the permanent magnet 7 can be improved.

[0105] In practice, because of machining allowances, surface roughness and other reasons, it is difficult to form the lateral surface of the claw in the circumferential direction of the rotor, the auxiliary magnetic pole portion, the auxiliary magnetic pole plate, etc. such that such a part is surely brought into contact with the whole of the magnetic pole surface of the permanent magnet. Looking from the microscopic point of view, there is a possibility that the lateral surface of the claw in the circumferential direction of the rotor, the auxiliary magnetic pole portion, the auxiliary magnetic pole plate, etc. are not perfectly in contact with (but just simply cover) the whole of the magnetic pole surface of the permanent magnet. From the practical point of view, however, such a case can also be regarded as in fact falling within the condition that the lateral surface of the claw in the circumferential direction of the rotor, the auxiliary magnetic pole portion, the auxiliary magnetic pole plate, etc. are substantially in contact with the whole of the magnetic pole surface of the permanent magnet. Therefore, similar advantages to those in the above embodiments can also be obtained.

[0106] Further, as a matter of course, the structure of the auxiliary magnetic pole portion 21' being effective to realize reinforcement of the strength and a smoother flow of the magnetic flux, and the structure of the flange 22' being effective to reduce noise, which have been described above with reference to FIG. 4, are also applicable to any of the above embodiments and the modifications thereof.

[0107] While the above embodiments have been described in connection with, by way of example, the vehicular alternator of the type that a current is supplied to the rotating field windings 6 through the brushes 13a, 13b, the present invention can also be applied to, e.g., a brushless vehicular alternator in which field windings are kept fixed. Thus, similar advantages to those in the above embodiments can be obtained when the present invention is applied to any type of vehicular alternator wherein a permanent magnet is disposed between adjacent claws of claw-type magnetic poles.

[0108] Also, while the flanges 22, 22' are provided in the above embodiments as a structure for preventing the permanent magnet 7 from ejecting outward of the rotor 1 due to the rotation of the rotor 1, the present invention is not limited to such a structure. For example, without needing the flanges 22, 22', a similar advantage can be obtained by employing a structure wherein each claw is formed to have a greater width in the circumferential direction of the rotor on the outer side than on the inner side in the radial direction of the rotor, and a trapezoidal permanent magnet is formed to have a greater width in the circumferential direction of the rotor on the inner side than on the outer side in the radial direction of the rotor, the permanent magnet being disposed between adjacent claws.

[0109] As described above, according to the first aspect of the present invention, since each claw of claw-type magnetic poles is formed to have a shape coming into contact with the whole of a magnetic pole surface of a permanent magnet, almost all of the magnetic flux outgoing from the permanent magnet is rendered to flow into the claw, whereby the resistance against a flow of the magnetic flux (i.e., magnetic loss) in the magnetic circuit formed by the permanent magnet can be reduced. It is therefore possible to effectively utilize the magnetic flux of the permanent magnet disposed between the adjacent claws of the claw-type magnetic poles, and to increase the output of the vehicular alternator.

[0110] Also, according to the second aspect of the present invention, since an auxiliary magnetic pole plate contacting the whole of the magnetic pole surface of the permanent magnet is interposed between each claw and the permanent magnet, almost all of the magnetic flux outgoing from the permanent magnet is rendered to flow into the claw-type magnetic poles through the auxiliary magnetic pole plates, whereby the resistance against a flow of the magnetic flux (i.e., magnetic loss) in the magnetic circuit formed by the permanent magnet can be reduced. It is therefore possible to effectively utilize the magnetic flux of the permanent magnet disposed between the adjacent claws of the claw-type magnetic poles, and to increase the output of the vehicular alternator.

What is claimed is:

1. A vehicular alternator comprising a rotor and a stator constituted by coiling stator windings over a stator core, said rotor comprising a pair of claw-type magnetic poles arranged in an opposed relation, a permanent magnet disposed between adjacent two of a plurality of claws provided on said pair of claw-type magnetic poles, and field windings coiled radially inward of said plurality of claws,

wherein each of said plurality of claws of said rotor is formed to have a shape coming into contact with the whole of a magnetic pole surface of said permanent magnet.

2. A vehicular alternator according to claim 1, wherein each of said plurality of claws has an auxiliary magnetic pole portion contacting the whole of the magnetic pole surface of said permanent magnet.

3. A vehicular alternator according to claim 2, wherein said auxiliary magnetic pole portion is formed to have a greater width on the outer side in the radial direction of said rotor than on the inner side in the radial direction of the rotor.

4. A vehicular alternator according to claim 1, wherein each of said plurality of claws is formed such that an inner surface of each claw in the radial direction of said rotor is substantially parallel to an outer surface thereof in the radial direction of said rotor.

5. A vehicular alternator according to claim 4, wherein said plurality of claws are interconnected by a substantially ring-shaped coupling member.

6. A vehicular alternator according to any one of claims 1 to 5, wherein each of said plurality of claws has a magnet holding portion for holding said permanent magnet.

7. A vehicular alternator comprising a rotor and a stator constituted by coiling stator windings over a stator core, said rotor comprising a pair of claw-type magnetic poles arranged in an opposed relation, a permanent magnet disposed between adjacent two of a plurality of claws provided on said pair of claw-type magnetic poles, and field windings coiled radially inward of said plurality of claws,

wherein an auxiliary magnetic pole plate contacting the whole of a magnetic pole surface of said permanent magnet is interposed between each of said plurality of claws and said permanent magnet.

8. A vehicular alternator according to claim 7, wherein said auxiliary magnetic pole plate has a magnet holding portion for holding said permanent magnet.

9. A vehicular alternator according to any one of claims 1 to 8, wherein a protective member is disposed at least on the outer side of said permanent magnet in the radial direction of said rotor.

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